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WHAT ARE THE DISEASES WHOSE NOTIFICATION SHOULD BE RENDERED COMPULSORY IN PORTUGUESE INDIA?

BY

DR. FROILANO DE MELLO,

Delegate of the Government of Portuguese India.

The compulsory notification of infectious diseases is one of the most important chapters of sanitary medicine in civilised countries and so important that it ought to be in the first rank of all sanitary and preventive works which have for their aim social defence against the invasion and spread of disease; but in order that the practical results which one has a right to expect may follow it is necessary that this measure be accompanied with a general plan of sanitary defence and medical aid.

It will not be out of place to call the attention of the Conference to this last subject; indeed, the problems which are related to it are of so complex an order from the economic, social, ethical, financial and religious points of view, that only the tenacity of the Government of British India aided by Science, of which my honoured English colleagues are unquestionably distinguished representatives, will be able to triumph for the profit of science and for the benefit of humanity. I am absolutely convinced that this subject will meet with the fullest attention of the Government of India and that the country, of which I have the honour of being the delegate to this Conference, will reap from it enormous advantages.

While I am speaking of English doctors in India allow me, Gentlemen, to render my most respectful homage to all those colleagues whose persistent and ceaseless scientific achievements have so largely contributed to the foundation of that still young branch of Medicine, Tropical Pathology. Gentlemen, your names are not unknown to us; we have followed your tireless researches, your books, your memoirs; your works are currently studied not only in Portuguese India, but in all schools of medicine in Portugal as well, and this scientific intercourse is only one page of the older bond which has united our two countries for so long a time. You will understand then perfectly, how happy I am to come here, to bring, at the same time as I am rendering you my personal homage, the assiduous and enthusiastic greetings that all Portuguese doctors send to their distinguished colleagues, subjects of his most exalted and powerful Majesty, the Emperor of India.

In what concerns Goa, of which a geographical map is attached to this memoir, medical aid is very well organized in the three divisions (*concelhos*) of the *Velhas Conquisitas*, Salsette, Bardez and Ilhas, and every measure of compulsory notification will be practically realisable there, because these districts possess numerous doctors, other than the sanitary officials of Government and Municipalities. As for their population, they possess a certain degree of enlightenment which should not be opposed to sanitary measures. I make, let it be understood, every possible reservation; the optimism of legislators often runs foul of the invincible barrier of public opposition and every one is well acquainted with the various episodes of the struggle, even in the most advanced countries, between the doctors and the people. I cannot say so much for the rest of the territory of Goa, known by the name of *Novas Conquisitas;* here the population is troublesome and ignorant, escapes constantly from medical supervision even in times of epidemic, has prejudices which are with difficulty overcome, inoculates itself with small-pox in order to propitiate the Divinity (Small-pox is a Goddess), and all this in spite of a vigorous propagandism of vaccination and the most energetic preventive measures. Medical aid is reduced to a minimum in *Novas Conquisitas* and until modern civil law is enforced in the Province, each district will continue under the care of a single doctor.

When I look at the question of compulsory notification from the point of view of prophylaxis, isolation, and disinfection, I am forced to confess that we have established nothing outside the principal centres of *Velas Conquisitas.* We do not possess a single sanatorium, and the education, manners and customs of the indigenous population in the greater part of our territory are not prepared at present for other useful sanitary measures.

The doctors here present are not I hope strangers to such a state of affairs, and in Portuguese India, as in British India, doctors will have to struggle during the next fifty years against popular opposition which only compulsory instruction in hygiene in primary schools will be able to surmount after long continued effort.

As for the notification of diseases I have divided the subject into two parts, in many cases only enumerating diseases about which I have not been able, for want of time, to accumulate sufficient data for a memoir.

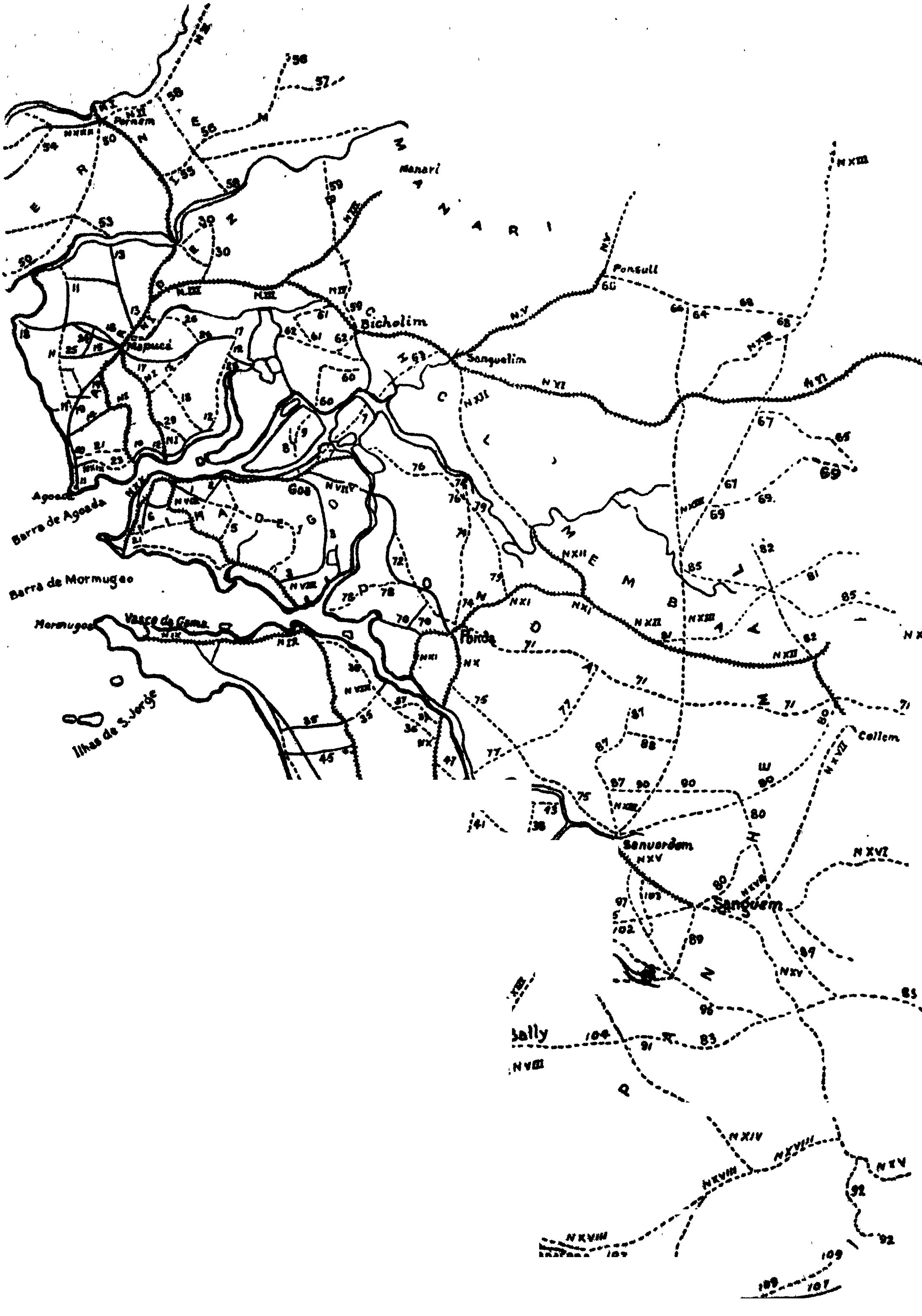
PART I.

Diseases of a known nature.

I propose compulsory notification of the following diseases :—

Plague.—This disease appeared at Goa after the invasion of Bombay in 1896. We have been attacked several times; each time plague has been introduced in our territory by merchandise coming from British India, mostly by land, sometimes by sea (two epidemics at Marmagoa, one at Pangim). Notification has been prompt and sanitary measures, taken with the utmost energy, have always succeeded in ridding our territory from plague.

On the subject of plague I have nothing to add to the findings of the International Conference at Paris in 1911-12, according to the interesting report of Dr. Calmette. I should like however to insist on one point to which the Sanitary Conference of Paris has not attached sufficient importance. Our researches, amongst


Pernem
Manari
Ponsull
Bicholim
Sanquelim
Mapuca
Goa
Agoada
Barra de Agoada
Barra de Mormugao
Mormugao
Vasco da Gama
Ilhas de S. Jorge
Ponda
Cellem
Sanvordem
Sanguem
Bally

MAP OF

which the first place belongs by right of conquest to those of the doctors of British India, show with a surprising degree of certainty that plague in India is essentially a disease of rats and that man is an accident in its evolution; that is to say, plague would have disappeared if rats could have been exterminated. This is a point no one would dare to controvert, but it should form the basis on which is founded the compulsory notification of this disease in India. A case of non-pneumonic human plague imported from a neighbouring country is not in itself dangerous to society; one infected rat imported into a country could, on the other hand, cause an epizootic and an epidemic of plague, and the chances of this happening are so great that nearly all our epidemics have had such an origin.

Considering then this as proved, I propose—

The Sanitary Conference assembled at Lucknow, while adopting the views on plague of the International Sanitary Conference at Paris, insists on the necessity of making notification of this disease compulsory in India at the time when cases of plague are discovered amongst the rats in the locality.

Diphtheria in Portuguese India.

For a long time it was accepted, almost as a dogma, that diphtheria did not enter into the list of diseases of tropical countries. The first cases of diphtheria at Goa were reported by Professor Wolfango da Silva fifteen years ago in a very interesting article which appeared in the *Medicina Contemporanea de Lisbonne*, and I believe this was the first occasion in which tracheotomy was performed in our country. Since these first cases, diphtheria has very rarely appeared, so rarely that one is able to cite the number of patients; 2 children at Margao in 1900, 3 at Pangim in 1906, 2 at Pangim two years afterwards, one in 1910, 1 at Ribandar (Dr. A. Costa), 2 at Pangim in 1911, 1 at Mapucá in 1913.

In addition there have been fatal sporadic cases of angina and of true diphtheria at Benaulim, Margao, Quepém, Gôa-Velha, Velçao, Mapucá, Siolim and Loutolim. Many of these cases have had a fatal termination in spite of diagnosis and early specific treatment.

It is possible that the clinical form which these cases of diphtheria exhibited may have been responsible in some degree for delays in diagnosis; indeed, very nearly all of them were clinically cases of simple pseudo-membranous tonsillitis.

I have good reason to believe that the numerous anginas which appear between November and January in Goa are of a diphtheritic nature. However, a bacteriological examination of these cases has not been made because they were not notified to the laboratory and for a number of good reasons, amongst them the most important being the very regrettable confusion between diphtheria and croup and the belief that all cases of diphtheria take the clinical aspect of croup. Proof of the diphtheritic nature of some of these cases has already been obtained by serotherapeutic treatment and I consider this proof as specific as is the toxi-antitoxic reaction in biology. Definite proof has been obtained by the isolation of the Loeffler bacillus from a case of pseudo-membranous tonsillitis, a bacillus that has given all the characteristic reactions of the diphtheria bacillus; a diphtheroid bacillus, Gram positive, characteristically stained with Neisser's stain, acidifies milk and has killed a guinea-pig in seven days: the guinea-pig had typical membranes in the vulva where the culture was injected superficially.

One point that merits our special attention in this connection is the relative rarity of the epidemic spread of diphtheria in Goa contrasted with what we see in

European countries. May it not be that the virulence of the bacillus is singularly attenuated and diphtheria shows itself chiefly as an angina ?

In British India, I believe, the disease occurs, and, if I am not mistaken, the first cases of diphtheria that Aldo Castellani of Ceylon published gave rise amongst the doctors of Lisbon to the question—does diphtheria exist in tropical countries ? In the actual publication of our colleagues of British India I see diphtheria very rarely reported as a prevailing disease, and it is perhaps to the absence of compulsory notification of anginas that this rarity may be attributed.

I have then the honour to call the attention of the Conference to the following proposals :—

(1) *The Sanitary Conference assembled at Lucknow, whilst recognising the existence of diphtheria in India, desires to call the attention of their colleagues to the multiple forms under which it appears and to the relative rarity of this disease in India compared with European countries.*

(2) *In order to be able to appreciate fully the extent and the epidemiology of diphtheria as well as a number of other questions relative to its most common clinical form and to the degree of virulence of the bacillus, this Conference proposes the compulsory notification of all suspected anginas.*

(3) *For confirmed cases of diphtheria all the measures of notification and prophylaxis in vogue in European countries are applicable to India.*

Typhoid Fever and some other diseases in Portuguese India.

Typhoid and paratyphoid infections are very prevalent in Portuguese India, especially during the rains.

The mortality is high, but I am, however, unable to show the Conference statistics to bear out this statement. Notification is compulsory in European countries and it has been made so in ours.

As for bacillary dysentery and kala-azar, I have not up to the present seen a single case of these diseases in Goa.

Amœbic dysentery is very prevalent in our country, as is malaria. I do not think that notification of these diseases will serve a useful purpose except in so far that it might enable a free distribution of emetine hydrochloride, the brilliant therapeutic results of treatment with which are due to Colonel Leonard Rogers of Calcutta (an anti-dysenteric campaign similar to anti-malarial campaigns by means of salts of quinine).

I think notification of influenza would be useful for in certain cases this disease has taken so virulent a form, and its bacillus so specific a *rôle*, that epidemics of fatal true influenza-pneumonia have claimed numerous victims, more especially in 1912, in Margao.

Cholera in Portuguese India.

Portuguese India has been constantly invaded by cholera. Interesting studies, as yet unpublished, that my colleague Germano Correa has carried out on the cholera epidemics of our country during the last twenty years, the reports that I have received from Doctors Rocha Pinto and Pantaleao da Noronha, and my bacteriological researches in some of these epidemics, have been utilized in the preparation of this note.

Cholera has often invaded our territory, the germ having been usually imported from British India, both by sea and land. The epidemic which ravaged

the *departments* of Sanguém, Ponda and Quepém in 1899, that, which commencing in Salsette in 1900, spread throughout the whole of Goa, attacking more than six hundred people, of whom nearly four hundred died, the epidemic of 1902, which was responsible for 126 cases and 62 deaths in Salsette and spread through Ilhas and Bardez, those of 1907 and 1908 at Salsette and at Sanguém, respectively, finally the virulent epidemic of 1911-12, all had a foreign origin.

The maritime channels of infection have been the ports of Tiracol, Betul, Talpona, Chapora, Mormugao and the shores of Salsette and Bardez.

In these latter the carriers of infection have been sailors of our province who go and fish in the ports of British India, and of these ports the most dangerous, from our point of view, have been the port of Badragodd (on the Malabar Coast in the South of British India), and the ports situated between Tiracol and Bombay.

Importation by land is at times by rail, at others along the whole line of frontier. The dangerous areas from this latter point of view are the ghauts where the working population settle so frequently.

It may be noted at the outset that all epidemics in Portuguese India owing their origin to importation, be it by land or sea, are very virulent and dangerous, have a greater tendency to spread than has the other class of epidemic that I shall describe soon, and are also usually preceded by virulent epidemics or pandemics in Central or Southern India, for example, the epidemics in Portuguese India in 1900 and 1902 were only an epidemic radiation of the cholera that devastated India between 1899 and 1904, more especially the Bombay and Madras Presidencies (G. Correa). It has been demonstrated that some of our epidemics have owed their origin to carriers. If this origin has not been proved in all cases which appeared to have arisen in this manner, the last epidemic of Bardez which invaded the villages of Oxel and Seolim was shown to have originated from a cholera vibrio carrier, a convalescent from the disease contracted in Bombay.

There is, however, another class of epidemics or sporadic cases in Portuguese India which are presumably due to a local or regional resuscitation of Koch's vibrio. The epidemics of 1897, 1898, 1901 (Bicholim), 1904 (Batagramma) were probably due to such a local resuscitation, but the most striking example of all is given by the last cases of cholera which occurred in Margao, Curtorim, and St. José d'Areal, and of which a very interesting report has been written by Dr. Pantaleao da Noronha (*Bol. Geral de Medecinae Pharmacia*, numero I, livraison II, 1913, à 1914).

At St. José d'Areal the outbreak commenced in the person of an old woman sixty years of age who had never been out of her village. No suspected articles were imported and cholera also appeared in Margao and Cortalim without any evidence of importation of the cholera germ.

This point is a very important one in the history of cholera in Portuguese India. A view that is commonly held by the doctors of our Province does not admit the "*cholera de reviviscence*" and attributes many of these cases to a distinct morbid entity called *cholérine*. This word ought no longer to survive. In the first place, climatic, hygienic, and social conditions of Portuguese India place it in the zone of epidemic radiations spreading from the Gangetic focus ; these conditions are very favourable to the development of Koch's vibrio.

These *cholérines* or choleraic diarrhœas are contagious (it is possible there may be diarrhœas due to other germs, coli bacilli, dysentery-like bacilli) for the most part and give rise to true epidemics, the character of which is, however, less virulent and less extensive, as Dr. G. Correa has admirably shown in his study of epidemic cholera in Portuguese India during the last twenty years. Finally I have examined

the stools of three patients suffering from this so-called choleraic diarrhœa or *cholérine* and I have been able to isolate a vibrio with all the characters of Koch's vibrio (shape, motility, indol reaction, non-coagulability of milk, non-hæmolytic, positive aggultination up to 1—2,500 with a serum 1—4,000).

In concluding this short account I have the honour to propose, bearing in mind that these so-called choleraic diarrhœas have been often neglected, and for this very reason have been the cause of genuine, though generally mild, epidemics :—

The Sanitary Conference assembled at Lucknow whilst accepting the views of the International Sanitary Conference of Paris 1912 *insists, on the one hand, on the necessity of deciding the question of vibrio carriers and on the other, compulsory notification of all suspicious diarrhœas.*

Tuberculosis in Portuguese India.

Tuberculosis is and has always been a social disease and every attention that the Conference pays to this subject will be of the greatest use and practical importance. This disease, not very prevalent twenty years ago, at the present time numbers numerous victims. It is not possible to give accurate statistics, but the replies I have received from 175 doctors allow me to state that tuberculosis is spreading at a truly astonishing rate in our country and that there is not a doctor who does not number in his practice more than 5, 6 or 10 patients suffering from recognized pulmonary tuberculosis.

The introduction of the Railway and the more intimate association that we have in consequence of it with British India, the ever increasing emigration of the inhabitants of Goa to India and Africa are the most important causes of the increase in tuberculosis in Portuguese India. Indeed, if we study the geographical distribution of tuberculosis, we see that the districts of our province of which the inhabitants lead the most secluded life and remain for the most part in the country, are the least afflicted by tuberculosis. All the *Novas Conquisitas* have so little tuberculosis that one could almost detail the families in which this disease prevails. In the *Velhas Conquisitas* it is easily understood that the villages which suffer most from Koch's bacillus are those which form the focus of most active emigration.

Christians suffer most ; the non-Christians, may be for the reason that they do not leave the country, may be for the lack of rational medical attendance whereby cases escape recognition by our doctors, suffer very little from tuberculosis. This cannot, however, be said as regards the Mahrattah and Moor soldiers of which a large number become tuberculous, more frequently even than their Christian comrades. It is the working classes which supply the majority of tuberculous patients in Goa.

But the disease claims its victims also amongst the prosperous ranks of society : it in fact levels all social classes, the misery of poverty and the misery of wealth.

Up to this point I have been speaking of classical pulmonary tuberculosis which I will call, with Piery and the French School of Lyons, *phtisie fibro caséeuse extensive.* But this does not bound the domain of tuberculosis and these data, which constitute undisputable facts, that the old clinician suspected and modern science has confirmed, make the question a singularly complicated one.

First the extent of tuberculosis is very wide : up to what point ought a tuberculous patient to be considered sufficiently ill to render notification of his disease compulsory ?

Gentlemen, I will not repeat here all the theories, all the opinions which in the years that have followed Koch's discovery have been advanced on this subject. You know full well that they would fill all the volumes of a library in which could be found arguments of every kind, some dictated by science and reason, others by heart and sentiment. We are still confronted with the formidable opposition that almost all the French medical world offered to the compulsory notification of tuberculosis, proposed by the "Académie de Médecine de la France" in consultation with the French Parliament, and after a wise and mature discussion which lasted sixteen long sittings and in which the compulsory notification of tuberculosis was so brilliantly defended by Richet, Chanveau, Roux, etc.

I believe however that the spirit of the Anglo-Indian people will not rise up against this measure because England is one of the countries (the others are Denmark, Norway, Pennsylvania, Berne, Quebec, New York, Germany, etc.), where tuberculosis comes into the category of notifiable diseases.

From this point of view it is useful to divide Tuberculosis into two great classes :—

(a) tuberculosis, the disease of the individual ;

(b) tuberculosis, a social disease.

The first includes :—

Tuberculisés which include hereditary tuberculosis without apparent manifestations, scrofulous subjects without obvious lesions, the infantile type of Lorain, lymphatic type, some abortive and latent cases, the *herpetisme* of Lanceraux, patients with erythema nodosa, pseudo-rheumatic tuberculosis, all the diseases belonging to the *petit tuberculeux* described in so masterly a manner by Poncet and Leriche. All these diseases react to tuberculins and although these re-actions are not of very great service in diagnosis and although they cannot be considered strictly specific, they are indications of organic susceptibility to Koch's bacillus.

These patients are not dangerous to society ; they can become so ; they may die of diseases quite other than tuberculosis. They deserve the most careful attention of the practitioner in so far as their individual health is concerned, but nothing more. The *tuberculisés* then need not be notified.

Individual tuberculosis includes another group of patients : all cases of latent non-pulmonary tuberculosis : such are arthritis, meningitis, enteritis, osteitis, Pott's disease, tuberculous pleurisy, and Poncet's inflammatory tuberculosis. The nature of some of these diseases is up to the present enveloped in obscurity which only the future will be able to clear.

These patients, above all when the disease assumes a form which makes diagnosis relatively easy, also need not be notified. They merit however the special attention of the Doctor, not only from the point of view of the individual health of the patients, but in order that possible sources of infection may be looked for in the patient's family and surroundings. I shall always recall an interesting article of Mons. Landouzy, which appeared in the *Presse Medicale de Paris* and in which amongst several examples one struck me as peculiarly suggestive : a child belonging to a well-to-do family died of tuberculous meningitis. All the other members of this family were perfectly healthy. There was no family history of the disease. The source of infection was looked for everywhere and was found in an old woman who had a chronic cough and who had been in immediate charge of the child in question. I myself have had a similar case in my practice. I had occasion to look after a *pottique* who died ; I thought that the infection had come from outside and to my great astonishment a year afterwards I saw the mother of my patient

phthisical, with cavities in her lungs and whose illness had begun with a slight cough five years before.

Nevertheless if these patients show tubercle bacillæmia they ought to enter into the category of "Tuberculosis, a social disease."

Amongst these "social tuberculosis" I include pulmonary tubercle which is not abortive and which has a tendency to spread, even though the disease may be in its first stage. Indeed the very recent studies of Kurashige (*Zeitsfur Tuberculose*, 1912, *analysé en Rev. d'Hygiène et Police Sanitaire*, 1913) show in the first place that the blood of these tuberculous patients frequently contains Koch's bacillus and that tuberculosis is a bacillæmia even in pretuberculous stages as well as in advanced phthisis. And the same author studying with Nayeama and Yamada (*ibid*) the milk of tuberculous women, even in the first stage of the disease, has found 17 positive cases out of 20 examinations; which confirms the fact that not only is tuberculosis a bacillæmia, the origin of this bacillary excretion (it must be noted that these bacilli were extremely rare), but it also explains why in the numerous *post mortem* examinations of infants, bacilli of the human type are found in the mesenteric lymphatic glands more frequently than are the bacilli of the bovine type which would be found extremely frequently if infection with bovine bacilli was dangerous.

(2) Confirmed, or better non-latent, pulmonary tuberculous, whatever be the clinical type of the disease.

(3) Laryngeal tuberculosis (this is, as is pulmonary tuberculosis, notified in Denmark).

(4) All non-latent extra pulmonary tuberculosis whatever may be its locality. Patients of this group of "social tuberculosis" ought to be notified.

There are however quite recent researches which deserve to be not only well known but also followed, because they represent a new day in this so complicated a question. I refer to the fine work which Professor Ponset, in his name and that of Piery, has presented to the *Académie de Medécine de France*. According to these authors, the sweat of tuberculous patients contains virulent bacilli, not only the sweat of pulmonary cases but also patients with tuberculosis of the peritoneum or joints. The experiments and the analyses on which the report presented to the *Académie* is founded are quite convincing; it would be as well however to await their confirmation.

In this same group the *typho-bacillose* of Landouzy ought also to be included. Up to the present time we do not know exactly what are the limits of this disease, nor have we any certain method of diagnosing it.

Gentlemen, the compulsory notification of tuberculosis, in spite of all the arguments which have been raised against it, is an accomplished fact and a sanitary law in such places as Denmark, Germany, Quebec, Pennsylvania, etc. It would be most desirable that India should also adopt it, and it is with this aim that I have the honour to propose :—

The Sanitary Conference assembled at Lucknow, believing that tuberculosis is and has always been properly called a social disease, proposes :—

(*a*) *that its notification should be made compulsory in all cases of pulmonary and laryngeal tuberculosis, and non-latent extra pulmonary tuberculosis;*

(*b*) *that other cases of tuberculosis call for the careful attention of Doctors in order that search may be made in the patient's surroundings for the source of infection;*

(c) *that Doctors of India should carry out researches as to the degree of tubercle bacillæmia in the different forms of tuberculosis and the prevalence and pathological anatomy of the typho-bacillose of Landouzy;*

(d) *when however latent cases of non-pulmonary tuberculosis show a tubercle bacillæmia, as one is entitled to think they may do after the studies of Poncet and Piery, such cases ought also to enter into the list of tuberculoses whose notification ought to be rendered compulsory;*

(e) *that the Conference hopes that Government, Municipalities, and philanthropic Associations will energetically encourage anti-tuberculosis campaigns.*

PART II.

Diseases of an unknown nature of which notification ought to be rendered compulsory.

Beri-Beri in Portuguese India.

Since I have chosen for my subject the compulsory notification of infectious and contagious diseases, the chapter of pathology which should have occupied the first place in my memoir is beri-beri; a disease of very recent importation, unknown to the greater number of medical practitioners of our country who have practised their profession there for more than 35 years. The disease has come very prominently to notice chiefly because of its high mortality, its symptomatology, and its behaviour with its genuine cases of contagion. Our astonishment when we read the proposals put to the vote at the last International Medical Congress, assembled in London between the 6th and 12th of August 1913, will then be readily understood. Happily the disagreement between the members of the Section of Tropical Pathology has left our knowledge of beri-beri at the same point where it was before the London Congress. One almost hoped, after the resumé of this work appeared in the Medical Press, that the various nationalities would abolish all preventive and quarantine measures so that the real truth as to the contagiousness or non-contagiousness of beri-beri, could be demonstrated.

Professors of the Medical School of Nova Goa and many doctors of Portuguese India who have had experience of beri-beri patients in our country cannot subscribe to the above opinion and it is for this reason, without wishing to run counter to the opinions of authorities holding contrary opinions, I wish to include it in the list of the infectious and contagious diseases and to describe, with as great detail as possible, the appearance and the spread of this disease in our country.

First Epidemic of Beri-Beri in 1912.

In February 1912, intimation was received from Valpoy of the outbreak of an epidemic of beri-beri amongst the expeditionary soldiers of the African Company and at the same time several soldiers who were attacked entered the military hospital. The cases were very interesting. The doctors of the Province declared that beri-beri was an imported disease unknown before 1908. On the other hand, the idea was spread that beri-beri had always existed in Goa in an endemic form called by the natives *nalkut, nalgut* or *naiakute.* Some even went so far as to say

that these so-called beri-beri cases were only patients suffering from *nalkut* and that *nalkut* was not beri-beri.

It was necessary then before diagnosing beri-beri to investigate this, and this I did with the help of my colleagues, Germano Corrêa and Baronio Monteiro, and the following is a resumé of our observations:—

Our Observations in the Military Hospital of Nova Goa.

1. *Beri-beri, confirmed, mixed form, subacute in type.*—Challi, a soldier of the Province of Mozambique—strong constitution; age about 20—25 years. The gait was not characteristic: painful œdema of the legs; general œdema, myalgia of the calves; neuritis of the tibial nerve trunks. Alteration in the tactile and thermic sensation, enfeebled reaction of the muscles of the leg to electrical stimulation: abolition of knee-jerk and plantar reflexes. Painful spot of Gayet; epigastric bar. Embryocardia or Malcompson's sign incomplete; carotid pulse from 120-135 pulsations a minute. Other organs were without any apparent abnormality. Urine contained neither albumen nor casts.

2. *Early beri-beri.*—Jiula, a soldier from Mozambique, age between 25 and 30 becomes rapidly tired after marching; dyspnœa after any exertion; tachycardia; wasting of the muscles of the leg; reflexes, sluggish; diminished sensation; pain on pressure over the course of nerve trunks; no œdema; organs normal.

3. *Early beri-beri.*—Sevigy, œdema most marked in the region of the internal malleolus; tibial neuritis; weakness of the muscles of the leg.

But apart from these patients sent to the hospital with the diagnosis of beri-beri, there were several African soldiers with other diseases. These were also examined from the same point of view, chiefly because some of them had been complaining for some time of pain in their legs which local applications often succeeded in relieving. One more beri-beri patient was discovered in this manner.

4. *Early beri-beri.*—An African soldier suffering from an inguinal hernia, tibial neuritis, painful œdema in the legs, weakness, tachycardia, etc.

This was without any doubt a case of beri-beri; the diagnosis forced itself upon one at a glance; we could not, however, rest there. Sometimes before, beri-beri had appeared in a disguised form amongst the garrison of the gunboat *Rio Sado* and I had often been instrumental in invaliding home to Portugal, sailors serving in this Province. As the natives captured by our troops during the revolt had been shut up in the gunboat, it was obviously our duty to examine the patients in the jail infirmaries. This visit revealed yet another three indigenous beri-beri cases.

5. *Confirmed beri-beri.*—Nanum Govinda Gauncar, a native of the province of Satary, Portuguese India; of feeble constitution, between 30 and 40 years of age; prisoner in the gunboat *Rio Sado*. Trembling gait, very characteristic; has had considerable œdema commencing in the neighbourhood of the malleoli: this has, however, become very much less: re-absorption of this œdema gives to the skin a dry hard consistency like a plank of wood, a sign observed by my colleague Baronio Monteiro. Reflexes and sensation almost normal, but according to the statement of the Doctor on duty they were at the beginning very feeble. Even at present the muscles of the œdematous region re-act very feebly to electricity; in the popliteal space the tendons present an abnormal degree of hardness, hindering the free movements of the knee. There is no albumen in the urine.

6. *Confirmed beri-beri.*—Sebastiao Fernandes, native prisoner: walks as if in water up to his knee, painful malleolar œdema. A curious fact is that the œdema began near the left knee. There is no albumen.

7. *Confirmed beri-beri.*—Babone Chamar, a native prisoner. Trembling gait; painful spots of Gayet, beri-beri bar, sensation and reflexes diminished.

If we come to describe in a synthetic manner the disease such as it has been observed in Goa, it will be easy for us to recognize in this syndrome a uniformity worthy of attention. The disease has always begun with pain; this pain is first a simple sensation of fatigue following a march; it soon becomes muscular weakness certainly depending on vasa motor disturbances. Later, without being able to definitely define the period, the painful symptoms change their character, becoming true pains, at the same time the muscles develop a certain degree of flabbiness; they tire very quickly under electrical stimulation and fail to respond altogether after three or four rapid stimulations. Let us analyse this pain in still greater detail. After walking it is no longer weakness but painful cramps that supervene. Pressure over the course of the tibial nerve chords gives rise to pain, often most acute. It is noteworthy that these latter painful phenomena are often localised in the region of the knee joint, giving rise at first to a suspicion that the case may be of rheumatism and which only subsequent history has confirmed as beri-beri. Œdema is the second sign in the chronological order and follows the muscular weakness. One is, however, unable to state what degree of cause and effect or coincidence there is between the œdema and the cramps or neuritis. This œdema has special characteristics; it begins behind the internal malleolus, but it may appear in other situations, for instance the knee, it is painful and to the touch the skin feels like a board, this hardness becomes very noticeable after the absorption of the œdema.

At this stage we have not observed any other organic change, not even gastro-intestinal troubles which are declared to be a precursory symptom of beri-beri.

It is quite true that some natives suffering from beri-beri have been attacked with amœbic dysentery which had however nothing to do with their actual disease. Remarkable above all is the absence of albumen from the urine, a sign which continued negative even in a serious case of œdematous infiltration which we had under observation.

It is very important that we should diagnose the disease at this stage because beri-beri in its early stages is readily curable by means of simple hygienic measures and symptomatic treatment. Later, all the symptoms described in books on tropical pathology supervene.

Our observations having been few in number, we are unable to compile up a more complete list of symptoms. We may however be permitted to say that all the cases of beri-beri in Goa have been of the mixed type of the disease, and have presented the following symptoms:—Anæsthesia involving, in a serious case, the thighs and the lumbar region. The patient does not feel the prick of a needle in the anæsthetic areas. Thermic sensation is less affected than the two former, although between the two conditions of abolition and slight diminution of sensation, every possible intermediate condition is met with. There is a zone of anæsthesia and hyperæsthesia; reflexes are diminished or abolished. The following are some of the painful symptoms observed in beri-beri patients that have passed the first stage of the disease:—Myalgia spontaneous or easily provoked; a painful bar in the epigastric region, complete or incomplete; the painful spot of Gayet between the second and third dorsal vertebræ and at the point of origin

of the eleventh dorsals : it may be noted that the second point of Gayet is situated between the ninth and eleventh dorsals.

Other organs are usually normal. In advanced stages dyspnœa (dyspnœa after exertion is also observed in the earlier stages) and cardiac lesions, embryocardia or Malcompson's sign, congestion of, and sometimes pain in, the liver supervene. To complete this description a little pathological anatomy founded upon the *post mortem* examination of Madew Pollo Mandrencar, a prisoner in the fortress of Aguada, confined originally in the gunboat *Rio Sado,* will not be out of place :—Hard œdema in the legs, on the right leg a very tight cord possibly applied to relieve pain : congestion of the lungs, congestion being more marked in the left lung ; fatty degeneration of the heart, large ante-mortem clot : hæmorrhagic effusion in the peri-cardial cavity, the liver granular and showing fatty degeneration. It may be concluded that the lesions found in the heart explain the sudden death, and that beri-beri was the disease from which the deceased had suffered.

We can then declare without any fear of contradiction that *the disease which in February* 1912 *prevailed amongst the African soilders and the native prisoners was indeed beri-beri.*

Beri-beri at Goa before the epidemic of 1912.

The first case of beri-beri in Goa was seen in 1908. Some sailors in the gunboat *Rio Sado* were attacked by it and sent back to their country : one or two died during the voyage. In 1910, the year of my arrival in India, beri-beri was hardly spoken of ; but a short time after evident signs of it were again seen in the naval hospital.

Our colleague, Sousa Machado, on duty in the gunboat, has often had an opportunity of studying beri-beri, and one of us has several times been on a medical board to examine patients with a view to sending them back to Portugal. A student at our Medical School submitted in his thesis, a typical description of beri-beri of the mixed variety and his very suggestive recommendations as to the accommodation of sailors in the barracks of the town have been published in the second and third numbers of the *Boletim Geral de Medecina e Pharmacia,* p. 181, (Contribuçäọ as estudo da etiologia do béri-béri por J. C. Provença Braganca). All the doctors who examined the sick sailors have been in agreement with the diagnosis of Dr. Sousa Machado and we can in this study dogmatically affirm :—*The sailors of the gunboat "Rio Sado" were in* 1910 *and* 1911 infected with *beri-beri.*

On the 11th May 1912, a prisoner, Buco Concubicar of Cotolem, a district of Satary, was admitted to hospital and during his stay passed through the hands of several doctors : on the 24th May, Dr. Viriato Pinto made the following notes about the patient in question :—

Buco Concubicar, married, agriculturist, age about 56.

Past history.—Malarial fever and suppuration of the external ear. Otherwise has enjoyed very good health ; the patient made some long marches as far as Belgao without having experienced any fatigue or swelling of the feet : not alcoholic. . His actual illness started in the gunboat where he was imprisoned and where his work was washing down the decks.

His feet are swollen and the swelling extends up to the legs and thighs, making walking difficult on account of the pain and fatigue that he experiences

at present. In addition he complains of a dry cough and shortness of breath. Dr. Viriato Pinto observed œdema, tibial neuritis, and atrophy of the left leg: cutaneous sensation abolished in the lower third of the leg and diminished in the upper two-thirds; absence of the plantar reflex, abolition of sensation to pain as high as the lumbar region: slight tricuspid murmur, râles scattered over the lungs; enlargement of the spleen. The patient recovered under treatment.

The Board of Health then ordered the boat to be placed under medical observation in order that prisoners with signs of beri-beri could be placed under treatment at an early stage of the disease. As a local defensive sanitary measure the order was issued that no prisoner would be allowed to proceed to his destination without a previous medical examination.

In June I was in charge of the patient, Buco Concubicar, and wrote that he was in a condition to leave hospital; however, as it was a question of a prisoner, it would be better for the director of the hospital to take the most convenient course. And the director replied:—" The patient should remain in hospital to avoid his return to the gunboat." These facts and resolutions coincided with our own wishes. This case of beri-beri had for us the nature of a laboratory experiment: it was the gunboat *Rio Sado* that was harbouring the germs of beri-beri.

The patient left the hospital the following month with a note from Dr. Sousa Machado. " It is necessary to know the destination of this patient in order that the sanitary authorities may keep him under observation."

From July to November there was a relative lull. It was the 14th of the latter month, that the hospital again began to receive beri-beri patients. The information of which the above is a *resumé* is of importance in the study of beri-beri at Goa.

The conclusion that this chapter forces upon one, corroborates the opinion of those who consider that beri-beri at Goa is dependent on importation.

A fresh epidemic in 1913, *occurring only amongst African members of the expeditionary force.*

After the 15th August 1913, a fresh epidemic began amongst the African troops; 40, 50, 60, soldiers, a whole company went down with it, and at the moment of writing (13th October) there are still patients suffering from it in the beds of the infirmary—the Lazaretto Reis Magos.

The clinical form is the same and what is important, many soldiers who had been attacked in February have relapsed again. I have good reasons for believing that the disease was resting in a dormant form in the people previously attacked and the germ, let us again use the word although it has not yet been discovered, again became virulent, facilitated by the condition of exceptional susceptibility that African races possess towards this disease, a predisposition to which attention has been drawn by nearly all authors.

It is important to remark that no native in the neighbourhood of the fortified posts occupied by the African Garrison has contracted the disease. If, moreover, the origin of this disease is feeding on husked rice, how many cases of beri-beri should we have in our country? To avoid making statements unsupported by credible data, I give a list of the chief food-stuffs of the poor native classes of our country according to replies received from the Sanitary Officers.

The native of Satary lives on *nachinim* (*eleusina indica Roxburgh*), *pacol* (*paspalum scrobiculatum, Linneu*), *orió* (*paspalum miliaceum*), rice (*orysa sativa Linneu*), and *sanvon* (*panicum crux-galli*). These cereals are usually eaten in the form of farinaceous cakes. Sometimes, though very rarely, so rarely that such occasions can be looked on as festivals, the food of the native of Satary is supplemented with cocoanut, palm sugar, lentils, setaria italica, and a little fresh fish.

According to official information the different cereals used for food can be divided up in the following manner :—

Eleusina indica	4
Paspalum scrobiculatum	2
Paspalum miliaceum	2
Rice	0·5
Others including condiments	0·5

In Salsette the principal basis of food is husked rice with very little *nachinim*, fish or meat.

At Pernêm, Sanguém, Ponda, Quepém, Canácona, Sanguelim, Bétul, etc., the diet consists chiefly of rice and the other cereals, very rarely fish and no meat at all amongst the non-Christian natives. In spite of this food not a single case of beri-beri has ever been seen.

If we now look at the rations of the African soldier we will be able easily to compare the richness of the soldier's diet with the poor miserable quality of the food of the native.

Before the epidemic :—

White rice	1	litre
White haricot beans in butter	0·2	
Cocoanut oil	0·25	
Beef or fish	0·2	

In case of scarcity of meat, a box of sardines preserved in olive oil, was substituted.

After the epidemic, on the recommendation of the Sanitary Officer—

Red-rice cured in Mangalore	0·5
Meat	0·5
Potatoes ..	0·3
Fish	0·4
Various vegetables	0·2
Various beans	0·2

And in spite of this change of diet beri-beri continued amongst the African company of the expeditionary force.*

What is the origin of beri-beri at Goa?

This question is a very complicated, delicate and difficult one to answer. Let us see what light our studies can throw on its obscurity. In the first place, we are up against two distinct opinions :—

(1) that beri-beri is a disease which exists in Goa in some endemic form ;
(2) that beri-beri is a disease that has been imported into this country and at a relatively recent date.

* Nearly all the patients are very anæmic. An examination of their blood has shown eosinophile, often amounting to 30 per cent. due certainly to intense infection with worms in the cases I have had occasion to examine.

Having consulted all old records, having searched everywhere for information, I was going to declare that beri-beri had never existed in Goa, although I was informed that a naval doctor studying an outbreak of beri-beri on the gunboat *Rio Sado* in 1908, had concluded that this disease is endemic in Portuguese India and is known amongst the natives under the name of *naikut* or *naiakute.*

It is necessary then in the first place to determine what *naikut* is. A disease characterised by generalised œdema (anasarca), which appears at all times of the year, and attacks all individuals without distinction of sex or age. Not a single instance of contagion has been observed. There is no fever; the characteristic sign is retraction of the umbilicus. The disease exists in all districts of Goa and doctors declare that cases of *naikut* which have not been treated by native drugs have been studied and are only acute nephritis.

The word "*nalgut,*" derived from the Mahratta language, signifies a swelling starting in the neighbourhood of the umbilicus. *Nal* umbilical chord, and *guta* obstruction, difficulty. *Nalgut* is a syndrome, possibly dependent on renal or hepatic disease. To sum up, the Indian disease called *nalgut* is not beri-beri.

What then has been the origin of beri-beri in Goa ?

The first cases of the disease made their appearance among the sailors of the gunboat *Rio Sado* during the time of the rains in a barrack which is used as a depôt for materials of war. It was said that the infection on the gunboat began with a Sergeant of Marines who contracted the disease at Lourenço Marques and who probably came to India without having completely recovered from the disease. Here he underwent a second attack exactly like the first, or perhaps a re-infection, and the naval Sanitary Authorities sent him back to Lisbon. It must be said, however, that this point has not been elucidated by my investigation : what is certain, however, is that soon after various officers and soldiers of the gunboat contracted beri-beri and were isolated in the convents of Velha-Gôa and the infantry barracks in Nova-Gôa, and the infection has continued surreptitiously attacking from time to time soldiers of the marine.

Since this first appearance there have been two recrudescences each time after the rainy season. At first sight it was thought that beri-beri might have come from the barracks or from houses situated in the near proximity. Superficial appearances seemed to justify this hypothesis, but more mature considerations immediately destroy these first impressions. Indeed, that portion of the barracks where the sailors stayed, was used formerly as a store for salt for the long period of 12 years (*contract du sel et abkary*), and not a single case occurred in Goa during these 12 years, although all the inhabitants of Goa consumed the salt that came out of these godowns.

For one year the regiment of Artillery was quartered in the same place. These barracks were used by the Infantry and the Band and not a single man of them ever contracted beri-beri. In the same line and forming part of the same building, and on the same level is the European Infantry barrack ; and quite close are some houses belonging to rich Hindus, and no one living therein has ever suffered from a complaint which was in any way suspected as being beri-beri.

Suggestions put forward that beri-beri originated from some houses of prostitutes have not been any more fortunate. These women are submitted to medical inspection and the servants of the hospital (Africans) that live in the same quarter have never evidenced the slightest trace of beri-beri.

All this is worth reporting and our attention ought to be specially directed to those cases which were due to infection contracted in the gunboat as well as in the fortress of Aguada.

The following conclusions can then be formulated :—

(1) beri-beri has not previously existed at Gôa ;

(2) beri-beri actually existing in Goa at the present time, is an imported disease ;

(3) although nothing can be definitely stated as to the origin of infection, one can say, however, that the primary focus developed in the gunboat *Rio Sado ;*

(4) one cannot state definitely whether the African soldiers contracted the disease at Gôa or brought it from Mozambique. However, my opinion inclines me to believe the first hypothesis : the place where they would have contracted beri-beri would be the gunboat *Rio Sado*, where these soldiers had for some days been on sentry duty ;

(5) judging from our experience in Gôa it can be affirmed that beri-beri is an infectious disease ;

(6) facts observed in Gôa contra-indicate the rice theory of infection.

Etiology and Pathology of Beri-Beri.

Beri-beri enjoys a vastly extended geographical distribution which can perhaps be subordinate to four important foci.

Asiatic focus from which radiations starting from the extreme east of Asia have reached the Malay Islands, Australia, New Caledonia and nearly all the Oceanic Islands, which constitute the—

Oceanic focus,
African focus,
American focus.

Europe has been free from endemic beri-beri, but slight epidemics are not rarely seen in the ports of Western Europe. One cannot say so much about ship beri-beri, because epidemics developed on board French and Japanese cruisers, demonstrate the existence of a ship beri-beri where no hygienic conditions are lacking.

The theories which attempt to solve this difficult problem can be classed into five groups : infectious, parasitic, toxic, alimentary and symptomatic. Let us begin the discussion of these by taking first into consideration the least likely.

The Symptomatic Theory.

Nocht and Durek maintain that beri-beri is a syndrome which develops in different circumstances and under the influence of various causes. Nocht divides his hypothesis and imaginary syndrome into three groups :—

(1) the infectious form of which the cause and mode of transmission are unknown ;

(2) the alimentary form due to imperfect food-stuffs ;

(3) the scorbutic form, due to troubles of nutrition.

This syndrome theory has no longer any supporters other than its inventors; it is not sufficiently scientific to be discussed seriously. In any case let us destroy it; it is false :—

1st.—because if it is a question of a syndrome it is not a question of a disease; a syndrome may be an episode in several and very varied diseases, whereas indisputable facts furnished us by pathology, pathological anatomy, and symptomatology conclusively show that beri-beri is a single, distinct, antonomous, and contagious disease.

2nd.—if it is a question of a syndrome belonging to different diseases, how can its endemic geographical distribution be explained, and, exceptions being made for slight variations that occur in the case of nearly all diseases, the fact that the disease always presents the same train of symptoms.

3rd.—if it is a question of a syndrome and not of a disease, how then explain its infectious nature. One knows perfectly well that defined as a syndrome it could only be classed in the group of diseases of nutrition or tropho-neurotic diseases of which none present the least degree of infectiousness.

There let us leave the fantastic theory of Nocht and Durek.

Parasitic Theory.

Giles and Walker have thought that beri-beri was a cachexia, dependent on infection by *Ankylostomum* or *Necator americanus*, because they have observed that many patients suffering from beri-beri harbour either *Ankylostomum* or *Necator*. It would be a scientific heresy in the present condition of pathology, bacteriology and tropical parasitology to admit the possibility of a parasitic causation of beri-beri. Because, in the first place beri-beri and virulent infections existing simultaneously in certain tropical climates it would be impossible in these regions and in such cases to make a sufficiently scientific separation of the etiological probabilities amongst the possible agents of infection.

2. Ankylostomiasis is endemic in certain regions with a temperate climate and even in cold climates in Europe and America. However, one does not see there the least trace of beri-beri.

3. There exist on the other hand certain climates in the tropics where beri-beri rages in endemic and epidemic form without showing the slightest trace of indigenous ankylostomiasis.

4. Finally to demolish absolutely the parasitic theory, there are parasites without beri-beri and beri-beri occurs without parasites.

Theory of Telluric Intoxication.

The hypothesis of telluric intoxication put forward by Manson and defended by Anderson, has no serious argument to support it.

1. Because beri-beri is often met with amongst people who wear shoes and have never lain on the ground.

2. Because if beri-beri infects in larger numbers people with naked feet, and those who in tropical countries sleep on the ground (the fact on which the theory in

question is founded), it is only because such people constitute the vast majority of poor people, living under bad hygienic conditions—conditions favourable not only to infection with beri-beri but equally with other diseases, which find in such people a fertile field for their development.

3. How also can one explain by this theory ship beri-beri which has been referred to above ?

Telluric intoxication is then an untenable theory in the face of modern science.

Alimentary Theory—Intoxication and faulty feeding.

Vanderman admits a certain degree of parallelism between the number of beri-beri patients and the degree of the husking of the rice consumed as food.

Fletcher thinks with Braddon that rice husked by mechanical processes is the only cause of beri-beri.

Fraser studying the effects of different varieties of rice on the working man in warm climates arrives at similar conclusions to those of the preceding authors who carried out their experiments in the Singapore Jails.

Muger suggests that the cause of beri-beri is feeding on salted fish.

Eyeckman incriminates white rice as the only agent capable of producing beri-beri.

According to Boussingault, the husking of rice causes beri-beri infection by the insufficiency of nitrogen that it brings about, whilst Brockmand and Laurent believe that it is the deficiency of fatty matters to which the infection of rice must be attributed.

This alimentary theory has still a certain number of supporters and they put forward certain reasons in support of it, but there are strong arguments against the theory :—

(1) Beri-beri from a symptomatic point of view appears in the guise of an infectious disease.

(2) Traver's experiment in the jails of Ol-Paol and Pudah-Paol, which is so often cited and which is the only one in favour of the alimentary theory, is surrounded by obscurity and should be republished with full details.

(3) Salted fish cannot be responsible for the production of beri-beri because there are many epidemics where the patients do not habitually eat fish and some where they have never consumed it.

(4) The argument of infection on boardship occurring more amongst passengers using native food, an argument very frequently put forward by partisans of the alimentary theory, has no value. These passengers are exactly those poor people who contract all diseases most readily.

(5) As for treating beri-beri by a change of diet, an argument of the supporters of this theory, this is also an argument of no value, for, putting a patient on a nitrogenous diet, is to put him on a stimulating one (see also changes in altitude and their value in the telluric theory) and the value of this in disease is well-known.

(6) There are some countries where feeding on rice is very widespread and in every form possible, and where, in spite of this, beri-beri is totally unknown. In Asia the great majority of rice-eating people remain free from beri-beri.

(7) If the cause of beri-beri has an alimentary origin (toxic or inadequate diet) and more especially husked rice, how explain beri-beri amongst those people who do not eat it ?

(8) How explain certain cases of the disease in those countries where the consumption of rice is relatively very small ?

(9) It has been conclusively shown that beri-beri is directly contagious ; this has been observed frequently in different warm countries, especially by Doctors of the French Army in Indo-China, by the Japanese in Japan, and the Dutch in the Islands of Java and Sumatra and by Doctors in Brazil.

(10) Unfortunately for humanity, but happily for epidemiology and tropical pathology, the existence of epidemics of beri-beri constitutes an indisputable fact, a fact which should be accorded its full meed of recognition.

In view of powerful modern scientific arguments, the alimentary theory is shaken and dies in spite of the energy it derives from imperfectly observed facts which allows it to linger almost to the point of extinction.

(11) The discovery and the isolation of the micro-organism of beri-beri will give the death blow to this theory. Let us then await this great event which will surely come in the very near future and in our own times.

Infectious Theory.

This is the most admissible and most certain explanation of the etiology and pathology of beri-beri.

The existence of direct contagion is undoubtedly proved ; the clinical course of the disease ; epidemics of beri-beri ; the efficiency of prophylactic measures ; pathological anatomy ; infantile infection by suckling ; and finally the almost worthless nature of the preceding theories are very suggestive arguments and constitute a solid basis on which to build the infectious theory.

Let us pass in rapid review the ideas of microbiologists.

Scheube, a warm defender of the infectious origin of beri-beri, adds that young and robust individuals contract beri-beri in the same proportions as others : beri-beri has a limited and defined geographical distribution and it does not attack with equal intensity those regions where it occurs in an endemic form. In Brazil and Java the disease is most prevalent during the hot and damp seasons, and adopts an epidemic character without any change in the diet of its victims ; according to Scheube bad feeding is a pre-disposing cause.

Balz believes that beri-beri is an infection of rice-eaters and its carriage to countries which are free from the disease shows its infectious nature.

In Japan it has been observed that the disease, for a long time confined to the large centres of population, has invaded the interior of the Nippon Islands without any change in the *modus vivendi* of the population with regard to diet.

Many micro-organisms have been considered as etiological agents of beri-beri. The " microbic filaments " of Salamon ; the " beri-beri protozoan " of Pereira ; the " micro-coccus rizicus " of Herzog ; Schubert believes that infection is transmitted by insects ; Van Corken by food and fæces ; Rost calls the beri-beri agent the bacillus cephalorachidicus, in view of the frequency of its occurrence in the cerebro-spinal fluid. Pekelharing considers the *bacteria beri-berica* the cause of infection. Dangerfield defends the specificity of his micro-coccus which stains only with difficulty by Gram's method ; this coccus is pathogenic for chickens and pigeons and the author says that he has found it in the blood, the vomit and the stools of patients. These researches have not been confirmed.

Wright believes that the disease is caused by a germ, localised in the stomach and duodenum, the toxin of which circulates in the blood and severely attacks the

peripheral nerves. His minimum experimental incubation period was between 8—20 days, during which there may be slight gastro-enteritis, appearing as indigestion.

Heonter and Koch in their researches in Hong-Kong have found in the blood of beri-beri patients a micro-organism resembling a staphylococcus staining with Gram.

Okata and Kokubo in Japan believe they have discovered a coccus which causes beri-beri, resembling a staphylococcus and which can be found in the blood, urine and fæces of patients.

Recently an eminent Japanese bacteriologist, Tsusuki, has announced the discovery of the cause of beri-beri, called the kakecoccus of Tsusuki, a diplococcus common in the urine, fæces, blood and cerebro-spinal fluid of patients. The kake-coccus of Tsusuki experimentally produces symptoms and lesions analogous to those found in human beri-beri.

Science has not yet said its last word about the kakecoccus of Tsusuki; but there is no doubt that beri-beri is an infectious and contagious disease which attacks patients especially when their resistance has been weakened by a defective diet.

Pre-disposing causes :—

(*a*) *Age.*—Beri-beri is exceptional in infancy, rare in old age, very common amongst adults.

(*b*) *Sex.*—It is more frequent among men.

(*c*) *Race.*—Negroes and the yellow races, not only because of their food, but also for ethnic reasons, present a certain morbid pre-disposition towards beri-beri.

The opposite of what occurs in the case of malaria is seen in beri-beri, a first attack, far from conferring immunity produces a pre-disposition for subsequent attacks of the same disease. Ought we not to look to this fact for an explanation of ethnic pre-disposition ?

To conclude, let us hear what Tsusuki in his masterly studies on beri-beri has to say :—"Rice is not the cause of beri-beri as swamps are not the cause of malaria; a marsh confers on those who live in its vicinity a pre-disposition to malaria by reason of facilities it gives to the breeding of anopheles; rice pre-disposes those who feed on it to beri-beri by preparing a more favourable biological medium for the development of the beri-beri germ."

These are the conclusions of Tsusuki :—Essential cause, infective agent; pre-disposing cause, rice; occasional cause, overwork. Gentlemen, I have just reported to you facts which are in absolute opposition to the acceptance of the rice theory. I hope that when the members of this Conference are framing resolutions on the subject of beri-beri they will take the facts mentioned above into consideration.

Remittent Fevers of Portuguese India, whose nature has not yet been discovered.

Among the diseases of an unknown nature of which notification should be rendered compulsory there are fevers which all my colleagues here present will most certainly be familiar with. I refer to remittent fevers which, having a course somewhat similar to typhoid, differ from it as well as from para-typhoid fever, may be from the clinical, may be from the bacteriological standpoint. This question has been the subject of very interesting and exhaustive research by the doctors of British

India, to whom I render here once again an expression of my homage and admiration. Having read quite recently a book by Major Roberts on "Enteric Fever in India," I have had the pleasure of seeing set forth therein the opinions of our distinguished English colleagues who recognize that the cause of these fevers is completely unknown to us, and others, whilst upholding the same idea, proclaim that they are of the nature of typhoid or para-typhoid infections.

I am not competent to speak on this subject, but I desire to bring to the notice of the Conference the modest contribution of my own work which has enabled me to proclaim that there are in Portuguese India fevers which having an epidemiological and clinical course very similar to that of typhoid, are nevertheless of a completely unknown nature.

But before describing them I must say, doctors have much abused the name "Remittent fever," including in it all febrile disturbances from the so-called remittent malaria to para-typhoid fevers.

The most clear description is that of Lieutenant-Colonel Dr. Wolfango da Silva, Professor of the School of Medicine of New Goa, who thinks that these fevers constitute a distinct pathological entity and can quite well be differentiated from other remittent fevers of Portuguese India.

The disease attacks all ages and sexes. It can be said, however, that it is rare in infancy and in old age.

Dr. Wolfango da Silva and his school affirm that these fevers are not endemic or epidemic and that he has never seen a case of contagion, it being extremely rare to see two or three cases simultaneously in the same family. But the majority of the doctors of our part of India believe in the infectious nature of these fevers. another point about which my studies do not allow me to make any definite statement.

It seems that these fevers confer a certain degree of immunity and relapses do not occur.

The course of the disease may be divided into three periods:—

(1) Invasion; (2) Aggravation; (3) Termination by death or by recovery.

It does not run its course in a definite constant number of weeks, for the first period can last three or four days; the second 2 to 3 weeks; the third such a period as to make the whole course of the disease last two, four or even eight weeks.

There are usually no premonitory symptoms; when they exist they are so little marked that the patients only take count of their disease, after they have had fever. In the evolution of the disease the only important sign is fever and it is on this sign that its division into periods is based by Professor Wolfango da Silva.

In the first period the temperature rises to a maximum of 102·5 or 102, the minimum being about 99 or 100.

In the second period the condition becomes worse; the maximum temperature rises, the remissions become less and less and the curve recalls to some extent that of typhoid fever, but in the latter there is a greater regularity in the rises and falls in the temperature chart. The maxima reach 104 to 105; the remissions are slight, and the fever becomes continuous or sub-continuous in type.

In the third period the course of the disease tends towards recovery, longer remissions occur, the maxima becoming less each day, the minima approaching normal. Often the fever becomes intermittent and the minima may fall to 2 degrees Fahr. below normal. A crisis has never been noted.

If one analyses more carefully the temperature chart it is seen that the fever can take two different types (temperatures taken every three hours). One sees

a rise and fall each day or even two. In the former case it is called simple remittent fever, in the second *fièvre remittent de deux croissances.* The first rise in temperature takes place between 3 and 6 o'clock in the afternoon, the fall commencing at the latter hour and continues to 10 A.M. If the fever exhibits two rises of temperature, the second rise takes place between midnight and 3 A.M., this rise is more persistent than the first.

There is no shivering at the beginning of the disease, but often headache, accompanied with pains in the neck ; the headache is severe but disappears the second or third day of the fever.

Loss of appetite is very pronounced, the tongue is moist and slightly fevered, of a yellowish colour if there be concurrent gastric catarrh. The typical tongue in this disease is coated, with red edges ; but if the patient becomes adynamic, which happens very rarely, the tongue may become very dry. The tongue, however, never resembles that of typhoid even if the fever lasts for 40 to 60 days.

Another very important symptom that I have myself been able to confirm is the regular and constant relation between the temperature and the pulse. In the case of all typhoid patients that I have studied, the pulse-rate was always relatively slow considering the temperature, whereas in the fevers that I describe, there is a perfect correlation between the pulse and the temperature.

The patient does not sleep well, but there is no true insomnia ; sleep is disturbed by dreams. There is often a symptom which has not so serious a significance as it has when it occurs in typhoid ; I refer to epistaxis, which occurs at the close of the first or commencement of the second part of the disease. At this period the patient develops low delirium and often hallucinations and true delirium, if the condition is grave and the debility extreme. The general condition improves immediately after the temperature begins to fall and the longer the remissions, the more pronounced is the improvement of the patient's general condition.

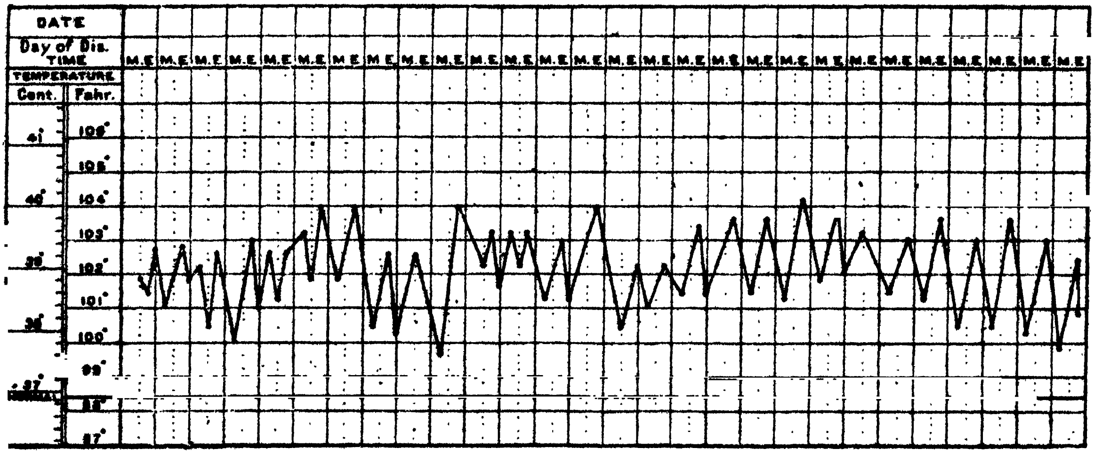
A fever of this kind, if well treated at the beginning, does not usually present any complications ; when these do appear they take the following form :—Stomach pain towards the end of the second period : lungs and bronchi—bronchitis towards the 8th or 10th day ; sometimes pulmonary congestion with thin serous sputa occasionally blood-stained : pain in the right hypocondrium due to distension of the colon. This pain is of such common occurrence that doctors usually employ blisters believing it due to hepatic congestion ; *subsultus Tendinum* and *carphologia* are of unfavourable prognostic significance ; it must be noted that these symptoms which are the rule in typhoid, even if it is well treated, only occur in very severe cases of these fevers.

Three to four stools a day, not very offensive : diarrhœa yields readily to treatment. The spleen is never enlarged. Intestinal hæmorrhage has never been observed : there is no tympanitis or abdominal distension. Bed sores so frequent in typhoid, have never been observed. The treatment consists in good liquid feeding, milk, farinaceous foods ; somatose ; purgatives ; bismuth ; gastro-intestinal disinfectants in the cases in which there is diarrhœa ; *cold baths.*

The prognosis is in general good, at any rate, in those cases that are treated from the commencement.

In studying the remittent fevers of India I have identified the typhoid bacillus by blood culture and by Widal's reaction : it corresponds perfectly to the masterful description which has been given by Professor Leonard Rogers of Calcutta.

CHART 1.


DATE
Day of Dis.
TIME
TEMPERATURE
Cent.
Fahr.
M.E
41°
106°
105°
40°
104°
103°
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100°
99°
37°
NORMAL
98°
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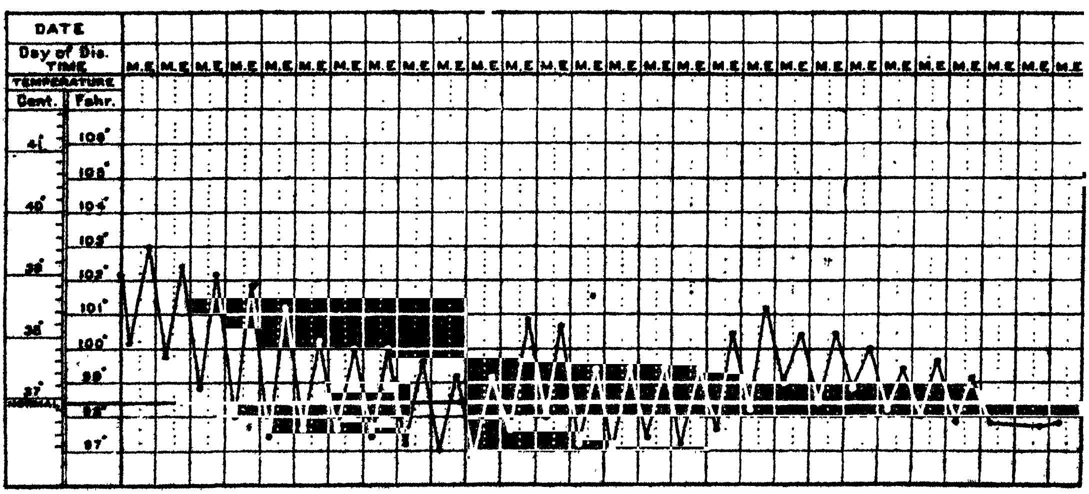
DATE
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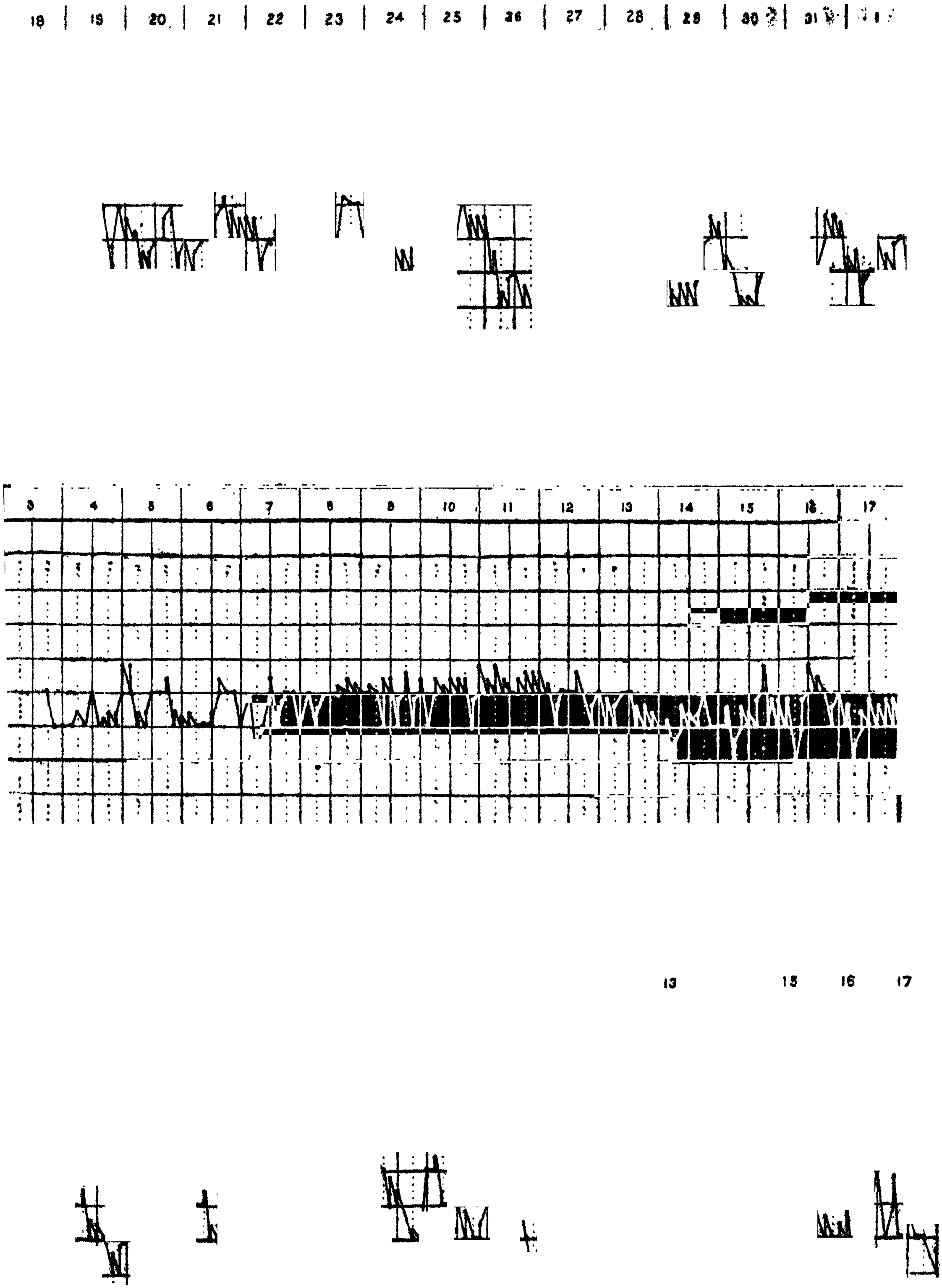
CHART II.


18 19 20 21 22 23 24 25 26 27 28 29 30 31
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
13 15 16 17

I have isolated para-typhoid B and some other para-typhoid bacilli whose characteristics do not allow of complete identification.

But I have found other cases which we have not been able to diagnose in spite of unremitting bacteriological research. I give temperature charts of two of these cases of fever whose nature up to the present remains unknown. In the first I tried Widal's reaction and blood culture—both negative. In the second, this patient was very severely attacked, I made the following investigations:—

5th day—examination of blood for malaria or other blood parasites; negative.

7th day—blood culture in peptonized ox bile—result, negative.

10th day—agglutination.

Eberth's bacillus—result negative.
Bacillus paratyphoid A—result negative.
Bacillus paratyphoid B—result negative.
Micrococcus melitensis—result negative (after warming the serum to 56°).

15th day—another blood culture—result, negative.

18th day—culture of fæces on Endo's medium: colon like bacillus, Gram—negative with the following reactions:—

Saccarose	—
Indol	+
Lactose	+
Glucose	+
Dulcite	+
Mannite	+
Levulose	+

Milk coagulated.

The serum of the patient did not agglutinate this bacillus. Intravenous inoculation of a rabbit with 1 c.c. of a broth culture gave no appreciable results. The bacillus does not appear then to be the cause of the fever.

20th day—Bordet Gengou's reaction with typhoid bacillus and bacillus paratyphoid A and B—result, negative.

25th day—Culture of urine: coliform bacillus (I don't think my assistant drew off this urine aseptically) with all the characteristics of the bacillus coli.

The results of my observations of these continuous fevers (which I am still carrying on) may be summed up. *There are remittent or continued fevers in Portuguese India which, according to laboratory studies hitherto carried out, are neither typhoid, paratyphoid, malta fever, malaria, nor kala-azar.*

Considering however that "remittent fever" is a term too commonly used by medical practitioners not only as a designation for typhoid and paratyphoid fevers, but the fevers of which I have just given a description as well.

Considering then that typical typhoid fever, according to the description of European authors, is rarely met with in Portuguese India, and that Widal's reaction is not available to the country practitioner to verify its diagnosis.

Considering that the perfect correlation that exists between the pulse and temperature is not only found in the fevers which I have described, but also in paratyphoid fevers and that the diagnosis of the latter can so rarely be made without the assistance of bacteriology and this is likewise not available to the country practitioner.

Considering also that the febrile course that I have described is very like that of typhoid and paratyphoid infections, and that the general clinical symptoms offer also many points of resemblance with those of these diseases, which makes us believe we are dealing with infections with bacilli of the same group, perhaps multiple infection, a point that calls for further research.

Considering finally that there are many doctors who affirm that these fevers are contagious.

I propose :—

(1) *that further research should be made to clear up the obscure points of this question ;*

(2) *that these fevers should enter into the list of those diseases whose notification should be rendered compulsory.*

Small-pox in Portuguese India.

Small-pox is a disease commonly met with in our part of India in spite of energetic propagandism concerning vaccination—so energetic that in less than 3 years more than 400,000 individuals have been vaccinated. We usually import the disease from British India and the epidemic develops in two ways, according as to whether the disease occurs amongst Christian or non-Christian classes. If small-pox appears amongst the former class, and does not escape observation, everybody runs away from the patient and in this manner attention is called to it, but if the patients are of the non-Christian class then they endeavour to conceal the case by all the means in their power from the sanitary authorities, and thus spread the disease amongst their relatives, the friends of their relatives, and the relatives of their friends.

However, prophylaxis is at the door of everyone and the law vigorously enforced in Portuguese India is a wise decree, dating from 1897, which I have had the satisfaction of putting into practice to the best of my endeavours.

It is true that in a country where the population is vaccinated, compulsory notification of small-pox need not be insisted on ; but vaccination is at present very far from including in its benefits a third part of the inhabitants of my country.

I propose then :—

(1) *compulsory notification in cases of small-pox ;*

(2) *that the Conference hopes that rigorous penal measures will be enforced by Government in all cases of concealment of small-pox patients.*

Measles and Whooping Cough in Portuguese India.

Considering that these two diseases attack infants of whom large numbers fall victims, and considering that infancy is entitled to special protection from the public authorities, I propose that measles and whooping cough should enter into the category of diseases whose notification should be made compulsory.

Gentlemen, at the end of this modest work, I shall be very happy to learn that the Conference has taken note of my proposals, and I desire finally to make one last proposal that may one day enter the realm of practical realisation.

Considering that many infectious and contagious diseases escape from medical supervision.

Considering that numbers of these same cases will not be notified for lack of accurate diagnosis and that this happens frequently, for example, in the case of tuberculosis, especially old bronchitic coughers, who even though they may die of intercurrent disease, do not fail to be a source of infection to their surroundings.

Considering that compulsory notification of infectious and contagious diseases is the first chapter of individual and collective prophylaxis.

The Conference hopes that every effort of Government and of municipalities will tend towards one day making disinfection compulsory in all cases of death, unless the doctor declares such disinfection to be unnecessary.

NOTE ON THE NOTIFICATION OF DISEASES.

BY

LIEUT.-COL. H. E. DRAKE-BROCKMAN, I.M.S.,

Director, Medical Department, and Sanitary Commissioner, His Highness the Nizam's Dominions.

THIS is, of course, one of the simplest and most efficacious agents we possess in preventing the spread of epidemic diseases in urban as well as rural areas. As regards an efficient system for the latter, I fear we are at present powerless to do much in this line, and must wait for the spread of education amongst the masses, and, by its aid, hope for the dissemination of hygienic principles and ideas amongst the population; still we have made some attempts in this direction (*vide* infra). As regards the former, however, I am of opinion that much can be done, and my experiences in connection with the recent severe epidemic of plague in Hyderabad City tend to confirm this.

A.—Urban areas.—Here we must rely largely upon the aid of the public and the co-operation of the local medical profession, but this can be aided considerably by simple but efficient measures with tact and zeal on the part of the staff of the Medical Officer of Health of any large city. Apart from an efficient reporting agency trained up to this work and to realise its extreme importance, there should be a few medical subordinates of the grade of at least that of Sub-Assistant Surgeon attached for this duty acting directly under the orders of every Medical Officer of Health of a large Indian city. The system adopted in Hyderabad, at my suggestion, has worked well, and enabled us to come into possession of such knowledge *immediately* upon its occurrence, and has, I feel sure, enabled us to nip in the bud many serious recrudescences of epidemic disease. Such arrangements are usually wanting in most places, and it is either due to an entire absence of such in many of our large Indian cities, or a perfunctory make-shift for them, that allows of epidemics obtaining a firm grip of the place before their presence is even known to the authorities!

The method briefly consists in the immediate report of all such occurrences to the Medical Officer of Health at any time by the sanitary staff, placed in charge of defined areas, who then at once deputes the medical subordinate in charge of such work (*e.g.* the Assistant Health Officer) *to proceed to the spot* and actually make enquiries into all such occurrences without delay, and, if possible, personally see and treat the case and do the needful, taking any preliminary steps that may be necessary to ensure the public safety—and immediately report same to, and, if need be, summon the Medical Officer of Health himself to the spot for consultation

and necessary action. In order to lose as little time as possible, for it must be admitted that time is a very important factor in such cases, a form has been introduced by me for use in the two Municipal areas of Hyderabad city (for owing to its vast size there are two separate Medical Officers of Health), in which the times are duly noted by the officials concerned in this work at which the reports pass through their hands until such reaches the highest Sanitary authority—*e.g.*, the Sanitary Commissioner to Government—for information. In order to prevent any chance of such reports reaching late or becoming lost in the post, they are sent by hand, and the actual times of despatch and receipt duly recorded thereon: I attach a sample one for inspection. In the November number of the *Indian Medical Gazette* in the review on the Hyderabad city plague report a gratifying reference has been made to this system by the Editor, advising that this system "might well be copied in other places."

I can say from personal experience that it has proved extremely useful to us there and been a powerful factor in the hands of the executive sanitary authorities of the place in the tracing out, and possible prevention of spread, of many of the common and destructive diseases existing in this country, especially as regards plague, cholera, and small-pox. The local Gevernment there have, at my suggestion, made it a penal offence not to report the occurrence of dead rats—which, at any rate in the detection of plague, is a move in the right direction.

B.—Rural areas.—The question of notification of disease in such is, of course, under present circumstances a very difficult matter, for the vast mass of the people are perfectly apathetic towards disease and show an attitude of indifference towards it, which it is difficult for the ordinary layman to conceive. It is usually only when it has attained such proportions as to create panic that one can get them to show any active co-operation in helping the authorities. At the same time there are signs prevalent that they are beginning to appreciate the value of health, and, the methods to retain such will, I feel sure, shortly follow. In my opinion we should make the start by having an efficient reporting agency scattered throughout each province carefully organized, so that we are not only kept informed of what is going on in these rural areas, but one also which is capable of acting on the spot in case of such emergency and advising the local authorities on such occasions. I have recently obtained sanction from His Highness the Nizam's Government to organize a Sanitary Department on these lines, each district is an independent unit with its local sanitary advisers and a complete itinerating dispensary in charge of a well-qualified Assistant Surgeon attached for duty therein, which is at the disposal of the District Sanitary Officer throughout the year, so that it is capable of moving about rapidly and can be despatched to the scene of any outbreak at a moment's notice or on occasion of large *melas*, or fairs, etc. I do not think that I can do better than to enclose copy of a departmental circular issued by me some time ago, which shows the duties and work of this agency for the early notification as well as treatment of all epidemics in rural areas in this State. If properly carried out, I feel sure it will be a great handle to us in meeting this question as a commencement in the solution of a very difficult sanitary problem. It can of course be considerably elaborated later on and extended as time and circumstances permit.

Notifiable Diseases.—I think that the time has come, at any rate in urban areas, to take some step in this direction, for I feel sure that public opinion will respond to it in most of our larger cities at any rate as being a measure of the utmost importance for the benefit of the public health and safety. I am of opinion that an

attempt should be made in the first instance to secure notification of the three most common as well as serious epidemic diseases, *e.g.*, plague, cholera and small-pox. A beginning might be made with these, for in most cases such are common and usually easily recognized by the people themselves, and by most independent private medical practitioners. Malarial fevers and phthisis might with advantage be added to this list, but the difficulty often of definite diagnosis thereof might lead to complications, for fever too, is, of course, a symptom of many other diseases. The active co-operation and sympathy of all medical practitioners would have to be enlisted in this important measure, and I feel sure that the early enactment of a Medical Registration Act in all provinces in India might go a long way to helping us to effect some improvement in this matter in many little way as such is likely in the long run to create a greater spirit of union and *esprit de corps* amongst medical men of all grades than at present exists, and, with it, more co-operation amongst its members for the public welfare.

SANITATION DEPARTMENT.

REPORT OF OUTBREAK OF EPIDEMIC DISEASE.

To

THE ASSISTANT HEALTH OFFICER .. .. Hyderabad City, Chadarghat.

It having been reported to me this day, that a suspicious case of.

has occurred in the person of one..................................son of ....age........caste.............residing in Mohulla ....in.........., I beg to request that you will be good enough to proceed AT ONCE to the residence of the above and investigate the circumstances of the case, writing your report* on the reverse of this for the early information of the Municipal Commissioner. The official making the report.........................is sent herewith in order to facilitate identification and investigation of the case.

Despatched.............$\frac{\text{A. M.}}{\text{P. M.}}$ on.......................19 .

Medical Officer of Health, Hyderabad City, Chadarghat.

* *N.B.*—This report on receipt should be *at once* forwarded to the Municipal Commissioner for information, and a report duly made to the Deputy Sanitary Commissioner at head-quarters at the same time.

HEALTH OFFICER'S REPORT.

I hereby certify that on receipt, I at once proceeded to the scene of the supposed outbreak and after careful personal examination and enquiry, am of opinion, that the case is one of.. and that I recommend,

Assistant Health Officer.

Despatched to Office of M. O. H. at.... $\frac{\text{A.M.}}{\text{P.M.}}$ on......................19 .

Received in „ „ at.... $\frac{\text{A.M.}}{\text{P.M.}}$ on......................19 .

Forwarded to Municipal Commissioner for information, at.... $\frac{\text{A.M.}}{\text{P.M.}}$ on......................19 .

Medical Officer of Health, { Hyderabad City, Chadarghat.

Rules for the information and guidance of the Subordinates of the Sanitation Department of H. H. the Nizam's Dominions as regards their responsibilities and action in the event of outbreak of epidemic diseases, such as Cholera, Small-pox, Plague, Epidemic Pneumonia, Typhus Fever, Typhoid Fever, etc.

SANITATION DEPARTMENT CIRCULAR NO. 1.

As there appears to be a great want of energy displayed in this matter, regarding measures to be taken on the outbreak of epidemic disease, the following rules are to be observed by Subordinates of the department on the occurrence of such events :—

1. In all cases when reports reach Subordinates, whether through Sanitary Inspectors, Police, Vaccinators, or other channels, that any epidemic disease has broken out at any particular place, more especially so in the districts of the Dominions, it is the duty of the Sanitary Assistant of the district to go at once to the spot and make enquiries as to its origin, spread, etc., the importance of going at once, and making this investigation cannot be overrated, and it is distinctly to be understood that this duty, of making the preliminary enquiry, is to be carried out by the Sanitary Inspector himself personally and not delegated to a Subordinate on any condition whatever.

2. In the event of any outbreak of such disease, the Sanitary Assistant will at once take any steps that he may think proper, in the case of outlying places, invoking the aid of the local Tehsildar, and then report the circumstances and facts fully to the District Sanitary Officer at head-quarters for further orders. In

this enquiry he should be most careful to enquire into the following facts, which are of great importance in tracing the course of an epidemic, *viz.*:—

(*i*) house in which first case occurred;
(*ii*) place of residence of first case;
(*iii*) whether come from a distance or resident in the village or city in which the outbreak has occurred;
(*iv*) the caste or castes of the cases attacked;
(*v*) symptoms accurately gone into on the spot;
(*vi*) if possible, personal examination of any cases still sick at time of the investigation in order to make an accurate diagnosis; and
(*vii*) a few minor details as to food and drinking water-supply, time of year, weather, previous occurrence of dead rats, prevalence of fevers and any undue mortality therefrom, etc., and any other facts gleaned on the spot personally from inspection and enquiry.

3. The result of this enquiry, together with a full account of the same with the details given above, should be forwarded without delay to the District Sanitary Officer at head-quarters for information and further orders and any action that he may consider necessary. All Sanitary Assistants are enjoined to make this report as full and concise as possible, as time is an object, for on this, the District Sanitary Officer will have to think over and take measures for relief, and aid where necessary in the way of applying for extra establishment, etc.

4. In the event of the outbreak occurring at a long distance from the head-quarters in which a Dispensary is situated, the District Sanitary Officer should, without further reference and on his own responsibility, make any arrangements temporarily for supplying medical aid, should it prove to be necessary, and any sanitary measures such as closing of wells, etc., that he may deem necessary for the purpose of preventing the spread of the epidemic; he should also take an early opportunity of communicating his suggestions to the Tehsildar of the district as well as to the nearest Thanadar in order to prevent any friction of any kind.

5. District Sanitary Officers have permission to detail District Sanitary Assistants and their itinerating dispensaries as well as vaccinators attached to their districts for any duty connected with epidemic disease, and they should take the opportunity of instructing these men, while they are working in the districts under them in the hot-weather months, in the due recognition and treatment of such diseases as Plague, Cholera, Small-pox, Dysentery, Pneumonia, etc., as well as Malarial Fevers, when epidemic.

6. The Sanitary Commissioner will, when on tour in the cold months, take special notice of Subordinates of the department who have followed these rules, and in cases where news of any epidemic reaches head-quarters, before the fact has been intimated to the Sanitary Commissioner by the District Sanitary Officer who is in charge of the district nearest to the scene of the outbreak, the subordinate responsible will be severely punished, unless he can show good cause for such omission.

7. The Officials of the Revenue and Police Departments will be asked to give every facility to Subordinates of this department in the conduct of these important duties, and be requested to keep them informed as to occurrence of such outbreaks.

NOTIFICATION AS A MEANS OF PREVENTION OF THE SPREAD OF INFECTIOUS DISEASES.

BY

DR. RAI KAILASH CHANDRA BOSE, BAHADUR, C.I.E.

IF the common adage "Delay is dangerous" has any special significance in the domain of preventive medicine it is nowhere so well illustrated as in the case where delay in timely notifying the appearance of an infectious disease in a house has resulted in the total extinction of a family or has been followed by an outbreak of an epidemic of the most virulent type. We all know full well that most of the infectious diseases are amenable to control and their early detection leads to their total eradication; but in emergencies our sentiments over-ride our reason and we refrain from doing anything until all hopes for their effective arrest are absolutely lost. The Corporation of Calcutta whose interest I have the honour to represent here to-day labour under a serious disadvantage from want of any definite law as to the notification of disease. During the last outbreak of epidemic dropsy every facility was offered to the people to co-operate with their District Health Officers in finding out means to arrest its extension, but they were inaccessible to reason and deliberately refused to do anything to help. Plague, which has taken a firm hold of India and which annually carries off thousands of her people, could be easily eradicated if the sanitary authorities could discover the first case during each recrudescence and deal with it in their own way. The failure of the vigilance committee to arrest plague dissemination was due more to the delay in discovering early cases than to any neglect on the part of the members themselves. It is to be regretted that our educated classes do not appreciate the value of timely notification of contagious disease; most of them, like the people of the dark ages, attribute the outbreak of epidemic disease to the will of God and as such to be averted by no human skill. The time does not permit further toleration of this superstitious notion of the people. The immortal Jenner has demonstrated beyond all shadow of a doubt that vaccination prevents small-pox and hopelessly paralyses its presiding deity Sitala, still the Indians do not advocate its use. I think and I believe that the time is ripe when vigorous attempt should be made to make notification of infectious diseases legally compulsory. All apprehensions for discontent and panic may be removed by announcing to the people that the notification act does not contemplate compulsory removal of the sick to a public hospital nor does it aim at the total destruction of their personal effects. Its scope is limited to the investigation of causes of diseases and prevention of spread by isolation of the patient in a convenient and suitable place in his own house and the free use of disinfectants. The medical

officer of health will be empowered to carry out these measures to his satisfaction. He should be instructed to exercise the power to be given to him with moderation and with as much elasticity as would be consistent with the operation of successful investigation. This would undoubtedly ensure ease and comfort to the patient and protect the healthy from catching the infection. Under the existing arrangement of things we simply fan the fire of infection and offer facility to its spread over a large area of a town and allow it to run its course unabated until time exhausts its virulence and the disease dies of itself and disappears from our midst. It is a matter of deep regret that only for the ignorance of its people the country should always pay a heavy toll to the assessor of death. Public health is public wealth. The State can ill-afford to lose so many of its subjects from preventable diseases. The sanitary authorities can do nothing to reduce the death-rate of a town or city until they get hearty co-operation of its people and co-operation does not necessarily mean an extra amount of labour or cost of money, but simply a report, verbal or written, to inspector of health or in his absence to any local responsible officer of Government, as to the occurrence of an infectious disease in their own or in their neighbour's house or cases which they are cognisant of. The task though very simple in its nature is still very difficult to get carried out. It is a municipal problem and its solution does not consist in formulating byelaws but in appealing to Government to legalize the notification of infectious diseases by an enactment.

The question arises as to what diseases are to be notified. Unlike all Western countries, India is hopelessly behind the age in matter, relating to health and sanitation. The majority of her people in their ignorance unwittingly create breeding-grounds for disease in their own houses and their social customs, rites and superstitions favour its dissemination both amongst themselves and their neighbours. Small-pox, plague, measles, diphtheria, german measles, epidemic dropsy, dengue, whooping cough, mumps, influenza, purulent conjunctivitis, tuberculosis and leprosy are all diseases capable of propagation by intercourse and contact and should be notifiable. The mere fact that the majority of the contacts do not become infected does not necessarily prove the non-contagious character of the disease itself. Certain conditions of health are necessary to form a suitable soil for the successful germination of the seed and its further development. Besides the diseases named there is another group of diseases which are communicated by means of contaminated food. These also should be notifiable and amongst them cholera occupies a prominent place. It is a formidable foe, which when it breaks out in an epidemic form, sweeps away people whose lives could have been saved if timely precautions had been taken to prevent its spread. This could be done only by immediate notification of its approach. Examples are always better than precepts and the administration reports of the health department of the Calcutta Corporation are replete with instances where villages, towns, cities and bustees have been saved from the ravages of the fell disease by active sanitary measures. It is true that cholera is not transmitted from person to person by mere contact; it is true that it only gets access to the system through the agencies of contaminated water and milk, but injudicious intercourse of the sick with friends and visitors creates opportunities of such contamination. Typhoid, paratyphoid, epidemic diarrhœa and dysentery belong to this class as they also spring from the same source.

The mortality from chicken-pox is nominal, but we are deeply concerned with its notification as it would afford us an opportunity to discover many a case of small-pox which sometimes simulates it most closely. The death-rate of measles is simply appalling and its early notification is the only remedy to arrest its progress and to

protect the neighbouring schools and hostels from its ravages. An infant suffering from mumps or whooping cough when not forthwith isolated will in no time spread the infection amongst the susceptible children of the house and of the neighbourhood. If the child be an inmate of a hostel or school he will contaminate the whole school necessitating its closure. The magnitude of the evil may be better imagined than described. The same may be said of diphtheria which in its unrecognised form resembles very much the ordinary quinsy and if the victim be allowed to move about freely, he will soon become a factor of dissemination of a dangerous disease. Time does not mitigate the potency of the germs of diphtheria. Regarding the other notifiable diseases no special remark is necessary since they are of daily occurrence and their symptoms are too well-known to need further description. The inclusion of continued fever in the list, will give rise to controversial discussion. Although some of the unclassified fevers of the country are not infectious and their isolation would be unnecessary, still if we consider the question seriously we must say that it is always wise to err on the right side, for nearly two-thirds of the cases of continued fever ultimately turn out to be enteric. The notification of successive cases of dysentery in a family may lead to the close inspection of the local dairy and to scrupulous bacteriological examination of water-supply. My apology in not including scarlet fever in the list of notifiable diseases is that it is not a prevalent disease of the country. It occasionally makes its appearance in Calcutta and always amongst a well-to-do class of men who know how to deal with it. Leprosy is not a rare disease in India, its notification is necessary to segregate the patient and to prevent him from marrying. It is an infectious disease and is transmitted to healthy people.

Instances are known where a wife has contracted the disease from her husband. The period of incubation is indefinite. How far the notification of tuberculosis of the lungs will be followed by wholesome results is a question which requires serious consideration. We know when unhappily a case appears in a family the patient cannot be easily cut off from his friends and isolated to the serious disadvantages of himself and those who are dependent upon him ; besides the disease always takes a protracted course. It would be very difficult to prevent movement of the patient, on the other hand if he is permitted to mix with his friends and family he will be a source of danger to them. Considering the rate at which tuberculosis of the lungs is spreading it becomes a duty incumbent upon the sanitary authorities of a town or city to forthwith adopt measures to arrest its further extension, and this could not be done without notification. It does not necessarily mean that we should confine the patient to his room, but we must teach him how to make himself comfortable and how to protect others from contamination. To consider the matter from the standpoint of health it would be necessary to make notification of Phthisis compulsory as that would enable the medical officers of health, to make special arrangement for its immediate arrest to increase the comforts of the patient by improving the environment of his room and to allow him as much fresh air as it would be possible under the circumstances. Disinfection of the room occupied by a phthisical patient and his furniture and personal effects should be done with as much care as would be necessary in dealing with a case of small-pox or diphtheria.

We must now consider the agency of notification in a country like India where the majority of the people are poor and illiterate, where heterogeneous systems of medicine are practised with perfect impunity, where imposters prosper at the cost of duly qualified men, where there is no municipal law to enforce death certificates and where sanitary measures are little appreciated by those for whose interests they are intended. Grave doubts are entertained as to the successful operation of a noti-

fication act at the commencement; but we trust that in course of time its beneficial effect will be amply realized by the sensible class of the residents of a town or city. It is idle to expect voluntary notification from the owners of houses; besides there are difficulties in their way and nobody else than medical men would be able to surmount them.

It must be admitted that there is always some amount of difficulty attending the early diagnosis of a case of measles and none but medical men would be competent to notify it. True it is that medical men are not often called to treat measles, german measles, and chicken-pox. It is imperative therefore that for the well-being of the community especially in a populous town or city that special sanitary inspectors should be appointed to examine cases free of charge and make house-to-house inspections where occasion demands it. In India the responsibility of the medical attendant does not cease with his reporting the nature of the illness to the owner of the house; he must duly inform the district health officer of the particulars of the case and the sanitary condition of the house where it has appeared. This would certainly take up his time for which he is entitled to a fee to be fixed by the local Sanitary Board. The Corporation of Calcutta pay one rupee to medical practitioners for the notification of each case of plague, and the result has been proved to be satisfactory. The senior members of the profession are above all such inducement and they gladly do the work without fee or remuneration.

I cannot conclude my paper better than by describing very briefly the two other advantages of a notification. The first is that it will afford facility both to the people and the authorities to trace out the sources of infectious diseases and by sanitary measures prevent their extension. It will also make the householder realise his share of responsibility to those who are dependent upon him and to his community, and how by a little care and trouble he could avert a peril which hung over him. It would give us a powerful means of combating infectious disease. If we examine the annual death returns we shall find that nearly 40% of the total number of deaths of India are attributable to preventible causes. The statistics of 6 years taken from the annual report of the Calcutta Corporation and which I append with my paper will clearly demonstrate the truth.

I repeat once more that in considering the question of notification of infectious diseases in an impartial way we shall find that its advantages are numerous and disadvantages *nil.*

Annual deaths from Preventible diseases in Calcutta.

Year.	Plague.	Cholera.	Small-Pox.	Measles.	Dysentery.	Enteric.	Phthisis.	Diphtheria.	Total number of deaths in Cal.	Deaths from preventible diseases.
1907	3,591	3,803	1,286	74	2,087	141	2,241	27	31,942	13,250
1908	1,779	3,694	578	220	1,677	142	2,049	34	27,689	10,173
1909	2,117	2,022	3,784	85	1,377	240	1,885	19	28,946	11,529
1910	1,262	1,901	48	240	1,470	330	1,878	46	23,728	7,175
1911	1,736	1,860	41	88	1,601	343	1,977	53	24,396	7,699
1912	1,831	2,244	77	96	1,709	367	1,931	56	25,209	8,311

TUBERCULOSIS IN INDIA.

SOME SUGGESTIONS ON ITS SPREAD AND PREVENTION.

BY

DR. W. J. WANLESS, M.D.,

President, Medical Missionary Association of India.

THE statement frequently made in recent years that tuberculosis is on the increase in India is difficult and probably impossible of positive proof. The reports of the civil and the private hospitals and dispensaries even if they showed an increase in tuberculous diseases, which most of them do, is not in itself positive proof of the increase of the tuberculosis inasmuch as European methods in the treatment of this disease have become increasingly popular in recent years, leading to increased attendance at Government and private dispensaries. However this may be, the experience of the writer during the early nineties as compared with that of the present time leaves the very emphatic impression that the disease in its various forms shows a marked increase in recent years. This I believe is the general experience of the more than three hundred Missionary doctors who for the most part are closely associated with the village and home life of the people; and I believe this is also the experience of civil surgeons and practitioners in general.

The statistics of the Mission hospitals with which I am most familiar serve to confirm this general impression. Whether there is an actual increase or not there is no question of the widespread prevalence and ravages of this disease especially among the educated and artisan classes of the large towns and cities and in our experience also among the village population. In the writer's experience the famine of 1900 and the plague outbreaks of previous and subsequent years have left in their train a legacy of tuberculous diseases. In times of scarcity and famine, and in recent years, during outbreaks of plague in the villages, large numbers of the labouring classes have been in the habit of migrating to Bombay in search of employment and immunity from plague. No inconsiderable number of these people contracting tuberculosis in the overcrowded chawls of Bombay have returned to their villages to spread the disease among their families and neighbours. Again and again the writer has come across such cases. The Christian cemetery at Miraj is largely populated by persons dying of tuberculosis, a large proportion of whom were children, students or teachers in Bombay Schools sent there from the Deccan during the last famine; and others who had gone to Bombay in search of employment.

That persons born and matured in the Deccan lose resistance against tuberculosis through residence in Bombay seems to be supported by experience. The

possible greater infectivity of Bombay as compared with the Deccan would not entirely account of this increased development of tuberculosis. Most of these patients referred to were students or teachers who lived in better sanitary surroundings and had better food and care than they had previously been accustomed to in their up-country homes. Add to this lowered resistance induced by the Bombay climate, the unsanitary conditions of the chawls and boarding places, it is not surprising then that Bombay has had unmistakable influence in the spread of tuberculosis among the up-country villages, and the same statement can probably be made in reference to other over-crowded coast cities.

Co-incident with the evident increase of tuberculosis in the mofussil towns and villages has been the increasing number of cases of tuberculosis of the glandular, digestive and osseous systems as evidenced by the increasing number of surgical operations now performed for the cure of those forms of the disease.

A speaker in the Madras Sanitary Conference made the statement that the people "did not need to be enlightened on sanitary points. They had sufficient knowledge of what was good and what was bad from a sanitary point of view." We cannot agree with this statement. Close contact with thousands of village people annually in dispensary and hospital practice serves to strongly contradict such a conclusion. We constantly observe that the majority of the village people, and even the educated, when placed in the sanitary conditions of a well regulated hospital show woeful ignorance of the first principles of sanitary laws, ignoring them as they do in many ways. The practice of relegating parturient women to the much ill-ventilated and unsanitary rooms of their houses is still a very common practice even among educated and well-to-do families. The writer has observed this repeatedly in the palaces of educated chiefs and zamindars. Added to these unsanitary habitations the lowered resistance of the puerperal state we are not surprised to find pulmonary tuberculosis, as one has found repeatedly, having its initiation under these conditions.

The practice of sleeping in rooms devoid of ventilation, with the head completely covered is still the rule rather than the exception even among the enlightened and well-to-do classes. The inherited dread of Indians to cold fresh air and the reluctance, often amounting to positive resistance on the part of tuberculous patients and their relatives to life in the open air, are still a common experience of every active medical practitioner.

The filthy practice of expectorating in any convenient corner of a room upon the wall and floor is a common observation of any one who has visited the homes of the merchants and middle classes. The filth swept into hall-ways of chawls and apartment houses with no one apparently responsible for its removal is still insistently repugnant to any one who frequently visits these houses.

While it is true that the majority of the inhabitants of India do not possess the means of providing sanitary surroundings, many simple means of sanitation which they already possess are not used owing to ignorance or custom. An illustration of what the average villager can and will do is the now well established custom of vacating their villages during outbreaks of plague. The value of this measure has come through practical education of the value of this measure.

Education in the prevention of tuberculosis is still the most urgent feature of methods to be adopted to combat this great white plague. It is indeed the *sine qua non* of all combative measures. The measures proposed in the excellent paper by Major Liston at the Madras Conference ought to be published far and wide throughout the country.

Last year I accompanied a Missionary touring party into a number of large towns and gave lectures to large audiences on sanitation and hygiene. On one occasion the lecture was given in the open air and practically the entire adult population of the town turned out to hear it. At the close of the lectures questions were invited and responded to. One had abundant evidence of the appreciation with which information on hygiene and sanitation is desired by the public.

As a supplement to the paper of Major Liston, I would respectfully suggest the following:—

1. The printing in all the vernaculars of tracts setting forth the causation, nature and effects of tuberculosis and the means to be taken to avoid the spread, to prevent personal infection, and of curative measures commonly employed. The tracts should be supplied to all the Civil, Municipal and private dispensaries and should also be in the hands of the heads and sub-heads of sanitary departments, Municipalities, and teachers in public schools.

2. The training of a class of assistant and sub-assistant surgeons who would be qualified to give regular courses of lectures on hygiene and anti-tuberculosis measures in the public schools.

3. A requirement that all Assistant and Sub-Assistant Surgeons in charge of Civil and aided dispensaries be competent to examine sputa for the presence of the tubercle bacillus, and the apparatus for this work supplied to all Civil dispensaries.

4. The periodical and special examination of children in public schools especially of all children who are known to the teachers to have persistent fever or cough; teachers should be required to report all such cases to the local Medical Authoity. All suspicious children in school should be isolated from other pupils during school hours and when positive evidence of the disease is found the children should be excluded from schools and parents advised to maintain separate sleeping quarters preferably, of course, in the open air.

5. The introduction into all normal school and training colleges of a special course on hygiene with emphasis upon the nature and spread of tuberculous diseases.

6. The erection of tuberculous shelters in connection with Civil and Municipal dispensaries.

7. Greater expedition in establishment of Sanitoria for tuberculous patients in suitable climates and where these institutions may be available all the year round. Two such established recently in Bombay Presidency are not available during the monsoon months located as they are in localities where the rainfall is very heavy.

8. Encouragement to the organization of anti-tuberculous leagues and societies by grants of money for the purpose of publication and distribution of anti-tuberculous literature.

9. The use of placards in public meeting places and on the public notice boards of the towns and villages displaying in large type some of the important "don'ts" of tuberculosis prevention as well as a few of the most important things to do.

10. Encouragement by Government to the development of industrial enterprises in commodious premises outside the cities and large towns and the development in connection with them of sanitary living quarters for the employees.

In order to the accomplishment of these objects a widespread appeal should be made to philanthropists and moneyed people of India to establish sanitoria and

otherwise co-operate with Government and anti-tuberculosis agencies in combating the great white plague.

A popular appeal for *a large central fund* to be raised for these objects should meet with a large response on the part of Merchants, Princes, Rajas, and others, to be used in a campaign of anti-tuberculous education, for the erection of tuberculosis sanitoria and shelters in villages.

In conclusion allow me in the name of the Medical Missionary Association of India representing over three hundred Missionary physicians and several hundred hospitals and dispensaries, to respectfully invite Government Medical and Sanitary officers to make a large use of this agency and of Missionary societies in general to co-operate with Government in the carrying out these objects particularly in the campaign of sanitary and hygienic education.

THE ORGANISATION OF ANTI-TUBERCULOSIS MEASURES IN INDIA.

BY

MAJOR A. W. R. COCHRANE, M.B. (Lond.), F.R.C.S. (Eng.), I.M.S.,
Superintendent, King Edward VII Sanatorium, Bhowali,

AND

MAJOR C. A. SPRAWSON, M.D., M.R.C.P. (Lond.), I.M.S.,
Professor of Medicine, King George's Medical College, Lucknow.

A CLEAR understanding of the sources of infection and the means of spread is essential to any co-ordinated plan for the control and eradication of tuberculosis, a plan which, for any hope of success, must be organised by public bodies, more especially by municipal and private corporations, in close co-operation with the State. A full consideration of the ætiology and spread of the disease will not, however, find a place in this paper, but instead a short enumeration of accepted facts and opinions on these points will suffice to introduce our subject.

Tuberculosis, the result of infection by the tubercle bacillus, is especially a house disease and dirt infection : it is fostered by bad ventilation and overcrowding. The sputum is the chief source of infection. Unrecognised cases, as well as uncontrolled cases of disease especially in the latest stages, are a source of constant danger to the community.

The disease is very common in children in whom the hereditary predisposition for the disease is of little importance compared with the state of their home, school surroundings, and the chances of infection, which, even for the children, is through infected sputum chiefly, though the danger of milk infection is also real.

The campaign against tuberculosis, which may be said to have begun in Europe some 30 years ago, and to be conducted now with greater rigour than ever before, is only just begun in India.

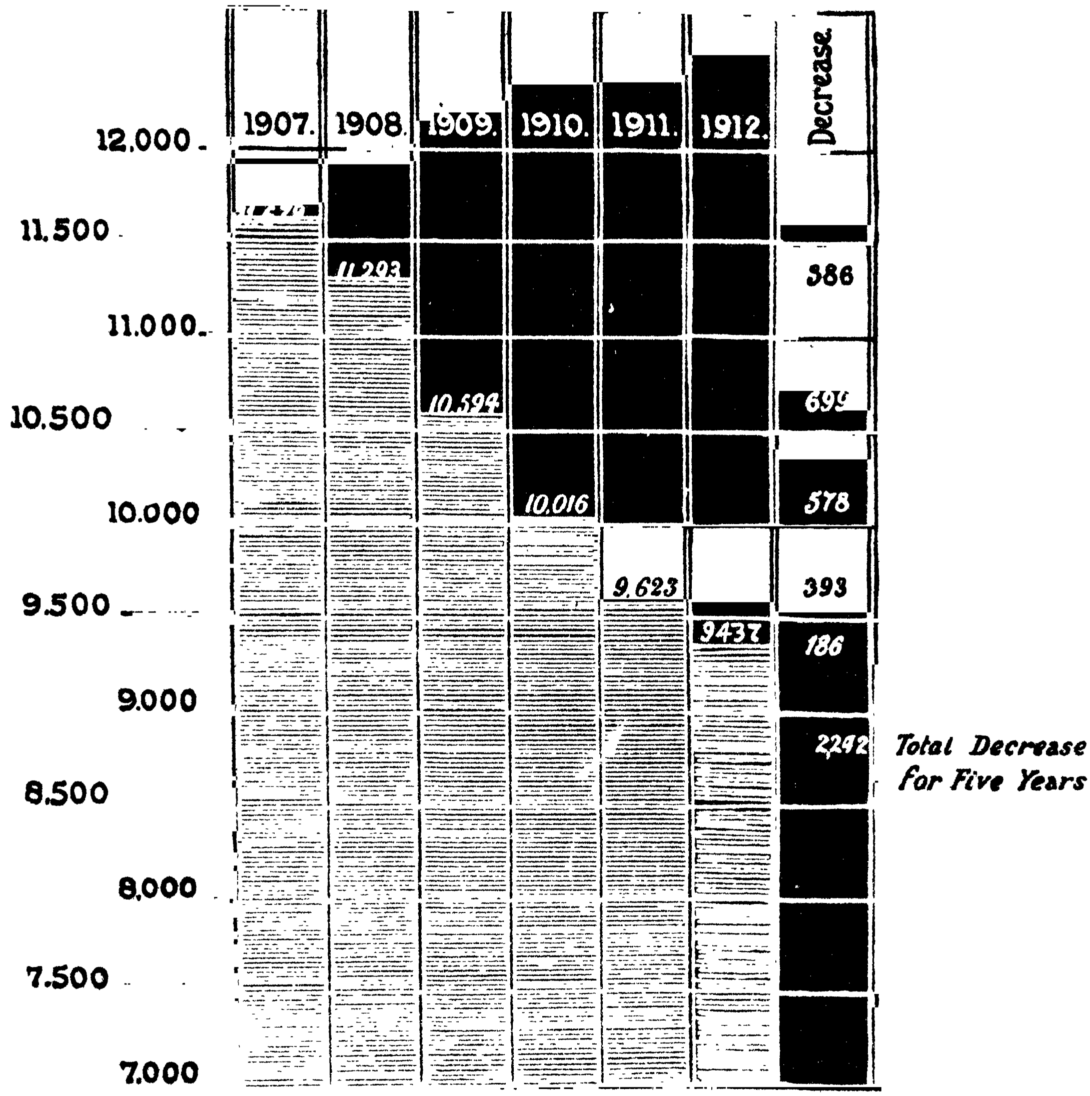
In twenty years some European countries have decreased their tuberculosis death-rate nearly one-half. Yet in the United Kingdom one-ninth of the total death-rate is still caused through tuberculosis. In Ireland, which is a country more backward in sanitation than the rest of the British Isles, and therefore has conditions more comparable to those in India, the improvement in the last six years when anti-tuberculosis measures have been more actively carried out is very marked. In 1907, 11,679 people in Ireland died from tuberculosis : as shown by the diagram on p. 43, the decrease has been steady until in 1912 the annual death toll is 9,437, a reduction of 2,242 per annum. Or in other words no less than 6 lives a day have been saved.

In India we do not even know how many we lose from this cause annually, our death statistics are so untrustworthy. But clinical experience is in favour of the belief that pulmonary tuberculosis is not less common in India than in Europe.

TUBERCULOSIS MORTALITY

IRELAND.

Diagram showing the decrease in the number of Deaths during the years 1907-1912



Our own belief is that it is commoner in Indian than it now is in English cities. Owing to lack of statistics we shall not, at first at any rate, be able to measure the success that we know we shall obtain. To obtain this success it is necessary above all to organise our forces, to have harmony in working, and especially to secure popular interest and co-operation in the war against the tubercle bacillus.

How to organise our efforts is the subject of this paper, and the means here suggested have been thought out by those who have had experience of them, or seen

them in working either in India or Europe or both, and have applied them so far as possible to the local conditions. Because of these local conditions the measures proposed are therefore no counsel of perfection ; but practical measures having due regard to the money at the disposal of the communities for whom they are intended, and to the customs and state of education of the Indian people. They are not therefore so advanced in their nature as the means now used in Europe, but there the fight has already been waging for many years, and the people are accustomed to the use of their weapons : we must first train our Indian people to do what they can with the means at their disposal.

For the purpose of anti-tuberculosis measures, communities in India may be divided into four classes according to the means at their disposal, the size of the community, and the purposes to be served by such treatment.

Class I.—Large cities possessing a medical school.

Class II.—Large towns not possessing a medical school.

Class III.—Other smaller municipalities.

Class IV.—All smaller communities and rural districts.

The outline of the various measures to be adopted is as follows :—

1. NOTIFICATION.

Notification of tuberculous diseases to the Medical Officer of Health should be compulsory in communities of class I and II. The practitioner notifying should always receive a fee of Re. 1 or Rs. 2 for each notification. Class III communities being as a rule not so advanced as those of classes I and II, compulsory notification

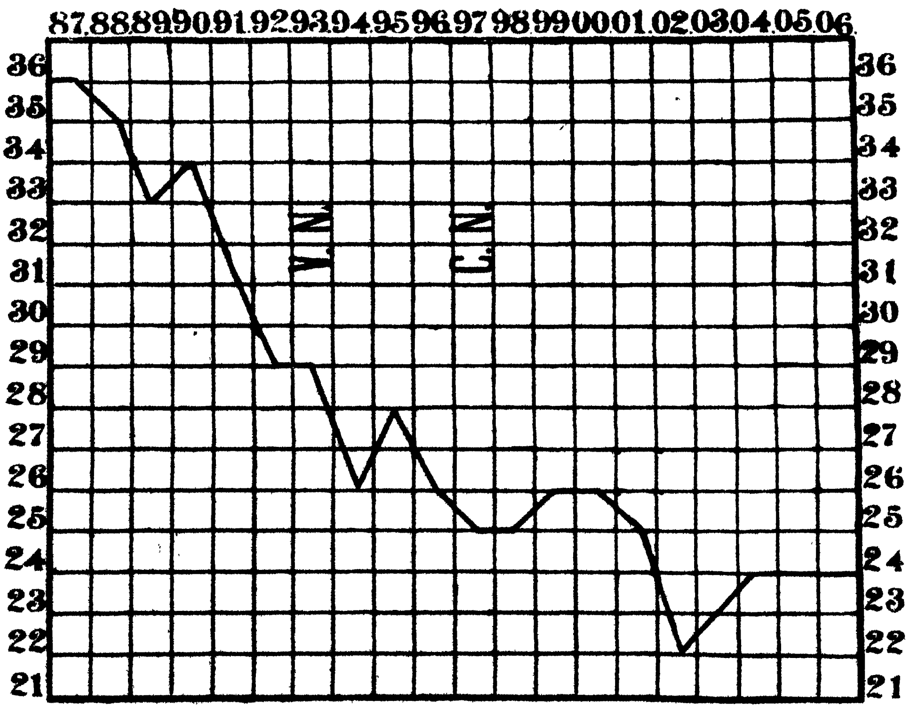


FIG 2 CHART SHOWING ANNUAL MORTALITY FROM PULMONARY TUBERCULOSIS IN NEW YORK DURING TWENTY YEARS

VN Voluntary notification. CN Compulsory notification.

cannot usually be demanded, though this should ultimately be aimed at. Notification may be voluntary, and the fee given in cases where it is made. The chart on p. 44 shows the relation of the dates when voluntary and compulsory notification respectively were introduced into New York to the phthisis mortality in that city. The relation may not be that of cause and effect, but an influence is suggested.

From the data obtained by means of this notification the Medical Officer of Health should maintain a tuberculosis map of the town, dotting off thereon the cases and deaths as reported. By this means he becomes aware of the areas where the disease is most prevalent and is able to take the measures that we will mention later on.

2. TUBERCULOSIS HOSPITALS.

Separate Tuberculosis Hospitals should be established in communities of classes I and II. In those of class III there will probably be no separate building availabe and part of the Civil Sadr Hospital should be set aside for the purpose. In class IV communities no such arrangements are possible, and patients can but come into one of the larger centres.

The importance of the early diagnosis of phthisis at branch dispensaries is a matter to be impressed on Sub-Assistant Surgeons, so that the patients can be sent in when still in an early stage and more amenable to treatment.

In towns of classes I and II the Tuberculosis Hospital should consist of an out-patient and an in-patient department. About tuberculin treatment as a method for use in the out-patient department we have written our experiences in another paper. Out-patients should be seen twice a week as a general rule. The in-patient department should if possible have separate wards for two classes of cases, the moderate cases and the advanced. To remove from patients in the 'advanced' ward the feeling of being considered hopeless, this ward can be unnamed and the ward for mild cases called the convalescent ward. These hospitals should have a nurse or nurses attached to them, on one of whom, besides her hospital duties, will fall the duty of house visiting mentioned below.

Tuberculosis Hospitals in class I towns should be in the medical charge of the physicians of the Medical College Hospital and should form a part of the teaching school attached thereto. That is to say, the students should attend regularly for a period of at least three months as clinical clerks and be signed up for such periods of duty. Such a course is now part of the usual curriculum at the King George's Hospital in Lucknow and is a part of the training required before admission to the M. B. B. S. degree of Allahabad University. We consider such a special training in tuberculous diseases, and in the uses and abuses of tuberculin, to be an important factor in the war against tuberculosis. There should be a special Resident Medical Officer in charge of these hospitals acting as a House Physician and Registrar to the Visiting Physicians.

In towns of class II there should also be a Resident Medical Officer, and, in the absence of a teaching staff, the hospital should be under the superintendence of the Civil Surgeon. In the larger towns of the United Provinces some such Tuberculosis Hospitals have already been initiated by the present Inspector-General of Civil Hospitals.

In class III towns, the tuberculosis wards and out-patients should, if funds will allow, be under the separate charge of a Sub-Assistant Surgeon who should be free from other work except that connected with such anti-tuberculosis measures as are described below. The object of such specialisation on the part of the medical

officer of the tuberculosis wards is that it is only by removing him from other subjects one can secure that special interest in his work which is necessary for the successful treatment of, and influence over, his patients. The personal factor in the treatment of this disease is such an important one that anything that will tend to enforce the personality of the medical officer in charge is to be favoured. A further function of these special hospitals is the instruction of the patient by word of mouth, by leaflets, and by daily example in the methods of avoiding infection. Nothing is so good an advertisement to a hospital, or so good an instruction in hygienic measures as an interested patient who has himself been improved or cured under such treatment.

Relation of the Medical Officer of Health to the Tuberculosis Hospital.

It is advisable to define here what relation the Health Officer or any of his assistants should bear to the Tuberculosis Hospitals or Dispensaries. The Health Officer should have no clinical charge whatever; his duties are entirely sanitary and should be devoted to the prevention of disease. Nor should an Assistant Health Officer be placed in charge of the tuberculous patients, nor should the officer who is in attendance on these patients be made subordinate to the Medical Officer of Health.

Experience in Britain has proved the mistake that such a charge is and the friction it gives rise to: the tendency there now is to regard the Tuberculosis Officer

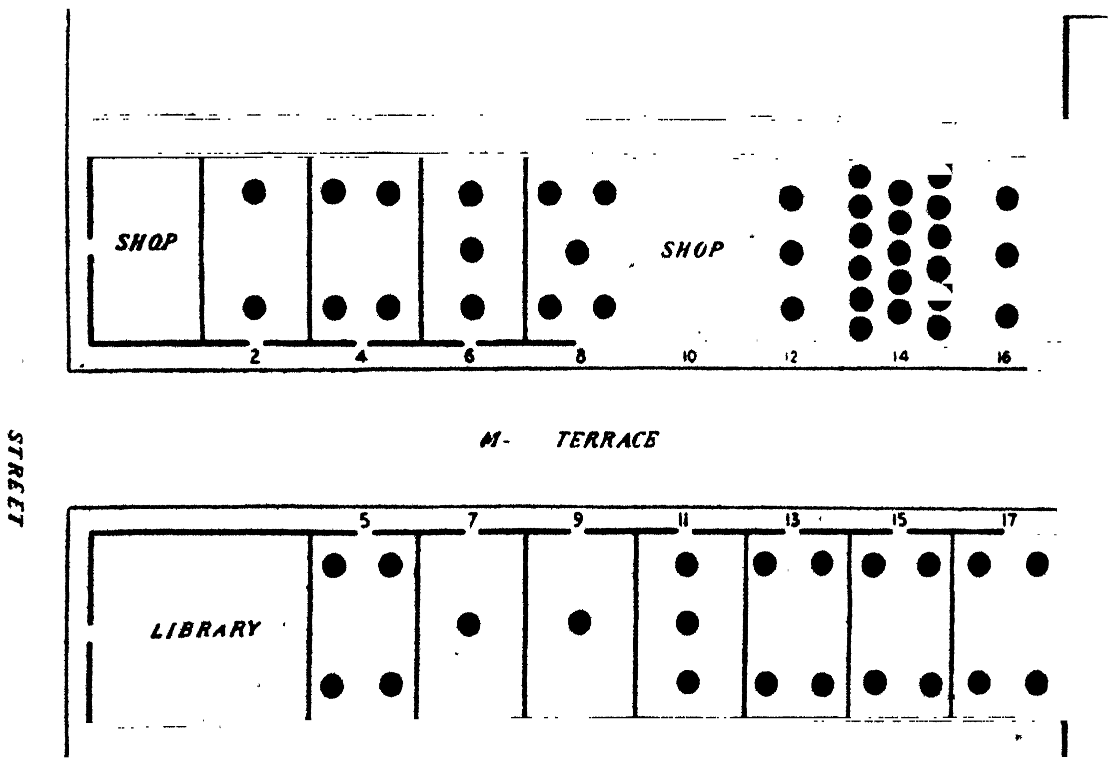


FIG 4.—ILLUSTRATING DISTRIBUTION OF PULMONARY TUBERCULOSIS THROUGHOUT A CITY POPULATION. EACH DOT REPRESENTS A CASE UNDER THE DIRECTION OF THE VICTORIA DISPENSARY FOR CONSUMPTION NOTE THE EXTREME FREQUENCY IN ONE HOUSE.

of a county as a clinical consultant on that special subject to the Medical Officer of Health.

In India the Tuberculosis Hospital and the Medical Officer of Health can come into relation in the following ways :—The Medical Officer of Health should, as is now done in Bombay, inform the Medical Officer of the Tuberculosis Hospital of the names and addresses of all tuberculous cases notified, and of all deaths from that disease. These houses are then visited by the nurse. The Medical Officer of Tuberculosis Hospital in turn notifies the Medical Officer of Health of the names and addresses of all such cases in his cognizance, so that from these and from practitioners' notification the Medical Officer of Health can prepare his map of the town showing the affected areas. Experience in other countries has shown that certain districts in each town are constant sources of infection, and that most of the cases will come from houses in these areas, and this fact should be borne in mind when the question of making new roads to open up congested areas or of erecting model dwellings comes forward. The special attention of the Medical Officer of Health should be directed to these districts in carrying out anti-tuberculosis measures and in stimulating landlords to house-betterment.

That pulmonary tuberculosis is to some extent a disease of house infection is illustrated by the diagram on p. 46, which shows a city street and the cases that occurred in it.

On becoming acquainted with such an area the Medical Officer of Health would, were it markedly insanitary, move the municipality to have the houses pulled down or altered in such a way as to remedy the defects. Through such areas new streets may, with advantage, be driven. If there is no flagrant defect about the houses of the affected area, the drainage will be attended to, disinfection carried out if allowed, and the inhabitants instructed in preventive measures.

Relation of the Medical Practitioner to the Tuberculosis Hospital.

It is important that our forces should be united in the war to be undertaken against the Tubercle Bacillus and especially that the Tuberculosis Hospital should work in harmony with the Medical Practitioner. If the hospital staff fail to pay due regard to the position of the practitioner in this matter it will establish a spirit of opposition on the part of the latter, who will consider both in and out-patient departments as subsidised competitors, attracting his patients away from him. This question is such an important one that it is well to read here short extracts from a recent paper dealing with the same subject in England, which country is naturally in advance of India on these points.

"The modern scheme which centres round the Tuberculosis Dispensary brings the Tuberculosis Officer into relationship with the general practitioner, and again it is necessary to delimit the respective functions. I suppose when the idea of a Tuberculosis Officer was first mooted he had no greater opponent than the general practitioner. That feeling is disappearing. In some places the understanding is that no patient is accepted for treatment unless authorisation is received from a medical man, usually the practitioner in charge of the case. Later on it is hoped that the Tuberculosis Officer will have general practitioners as assistants in the dispensaries. These two provisions will be a sufficient guarantee against the dispensaries being used by persons from whom they are not intended. For the rest, the Tuberculosis Officer does not inflict his attention on the unwilling doctor, but is ready to be of any use he can either in or out of the dispensary to such as wish his assistance."

Such are the lines also upon which the Tuberculosis Hospital in Lucknow is conducted. To prevent, as far as possible, ill-feeling on the part of practitioners enquiry is made from every patient applying for treatment as to his previous medical attendant, and to the latter, if he be a practitioner holding a recognised qualification, a communication is sent enquiring if he has any objection to his patient attending the Institution. This precaution is all the more advisable in a country where medical ethics are so little recognised. Moreover every assistance should be given to the practitioner in the diagnosis of his cases by the methods available at the Tuberculosis Hospital, such as examination of the sputum, tuberculin tests and mapping out of physical signs. It is not advisable to give the patient this diagnosis : he is sometimes inclined to take his chest chart and results of his tuberculin tests, and carry them together with a growing file of prescriptions from one doctor to another. To discourage this so far as possible the result of any diagnostic method should be communicated privately by post to the patient's doctor. It is understood that any patient who can afford to pay for such examination should have it done at one of the private laboratories where such exist.

There are three classes of patients practitioners are inclined to send to Tuberculosis Hospitals ;—

1. Doubtful cases for diagnosis.
2. Patients who, having commenced treatment, are unable to continue the payment of the necessary fees.
3. Advanced cases whose end seems not far off.

We have already spoken about cases for diagnosis : in the other two classes practitioners should also be helped as far as possible, and the advanced cases admitted if they consent.

In concluding our remarks on Tuberculosis Hospitals we will quote from the paper of that great authority Sir Robert Philip at the recent Annual Conference of the National Association for the Prevention of Consumption, that the centre for anti-tuberculosis measures must be the Tuberculosis Dispensary. He goes on to say "The real working centre of operations against tuberculosis could not be the ordinary out-patient department of any hospital, or the Charity Organisation Office, or even the office of the Medical Officer of Health " though with all these the dispensary must be in closest touch."

3. TRAVELLING EXHIBITIONS.

Popular exhibitions, demonstrating in a simple manner the source of tuberculous infections, the nature of the disease and the means of combating it, have proved successful in Great Britain. They travel about the country, halting in important towns, where demonstrations and lantern lectures in a popular form are given. Such exhibitions and demonstrations are suitable for towns of classes I, II & III ; they should be modelled on those given in England, and one or two simple lantern lectures delivered in each town. The opportunity should then be taken to distribute popular leaflets about tuberculosis written in the vernacular and explaining in as simple a manner as possible the means of prevention.

Such exhibitions and lectures might be conducted by the Deputy Sanitary Commissioners : it should be sufficient if each town were visited every second year.

4. PREVENTION OF SPITTING.

There is little doubt that the principal cause of phthisis is the inhalation of dried sputum : and the freely expectorating habits of the people both in their homes

and outside, add to the frequency of this form of infection. Something has been done already to lessen this in Government buildings; but the rules should be made more strict and applied to Railway stations and carriages, schools and other public places.

It is probably, however, in the homes that infection mostly occurs. The people spit very freely in their homes especially after smoking or eating *pan;* they use a vessel as spittoon if it is at hand, if not the expectoration goes on the floor or wall. Afterwards the vessel is cleaned out on to the ground or into a drain. The leaflets that are distributed should impress on the people the importance of—

1. Spitting as little as possible.
2. Spitting only into the spittoon.
3. Emptying the spittoon into the privy whence the contents can be removed with the foul matter.

Sputum that is known to be tuberculous should always be burned; but for ordinary purposes emptying the vessel into the latrine pail is to be recommended, as more likely to be carried out.

5. INSPECTION OF SCHOOL CHILDREN AND SCHOOLS.

All school children should be individually inspected once a quarter at their schools for the detection of early cases of phthisis, enlarged glands, bad teeth or other causes of ill-health. Tuberculous cases should then be sent to their doctor or to the Tuberculosis Hospital. The inspector at his visit should report to the education authorities on the hygiene of the school, and note if the time table is so regulated that the exercise does not suffer. Methodical breathing exercises in the open air should be an obligatory part of the time table and be reported on by the inspecting doctor. This inspection should be done by the Health Officer of the Municipality or a qualified assistant in towns of classes I, II & III. No such arrangement in class IV communities seems practicable.

6. HOUSE VISITING.

The best means of all for securing the cases of tuberculous disease among the poorer classes in their early stages, and especially in children, is the house visiting of one of the nurses of the Tuberculosis Hospital. The nurse has the addresses of patients attending the hospital, and receives from the Medical Officer of Health the addresses where a death from phthisis has recently occurred. She visits the home and after tactful conversation sees the children and other inmates, gives advice, and distributes leaflets on the subject. Any case of suspected tuberculous infection she encourages to go to the Tuberculosis Hospital for diagnosis and treatment or else to their usual doctor.

This system first introduced in Edinburgh works excellently there and very well in Bombay. The essential to success is the personality and tact of the nurse. It will probably be necessary to employ a European lady and to pay her not less than Rs. 150 a month : in Bombay she receives, I think, Rs. 180 and her ghari hire.

7. IMPROVEMENT OF THE MILK SUPPLY.

The better control of the milk and ghi supply and the establishment of Model Dairies are matters now engaging the attention of Sanitary Commissioners, and upon the Provincial Sanitary Departments working in conjunction with Municipal Health

Officers we must depend for improvement in this direction in towns of the first three classes.

The relative importance of milk in relation to tuberculous infection in India is as yet unsettled: it is, however, certain that Indian milk is exposed to much foul contamination, mostly bovine, in dairies, and the prevention of that—since tubercle bacilli are to be found in the fæces of infected cattle—will go hand-in-hand with removal of tuberculous infection.

A recent investigation in Cawnpore taught us that 3 per cent. of cattle showed tuberculous lesions *post-mortem*. Most probably a larger percentage are infected, but except on a small scale in Bombay no tests on cattle in India with tuberculin have yet been published. We hope for more information on this point before very long.

Mr. Stiles in his recent paper read before the International Medical Congress stated that of his cases in Edinburgh 61 per cent. of the tuberculous bone and joint diseases in children were due to the bovine bacillus, and of the enlarged cervical glands no less than 90 per cent. This implies infection from milk. We are not, however, justified in assuming the same for India; further investigation is required.

8. IMPROVED DWELLINGS AND TOWN PLANNING.

In the larger towns of India much is already being done towards the opening up of congested and insanitary areas by new and broad streets, and by demanding a better type of house in the Municipality. As the building of better and more pucca dwellings for the poor is the one sanitary measure that strikes at the root of other classes of infection, besides tubercle, notably plague, it is the one above all to be encouraged: and it is upon this better housing of the poor, which is moreover a permanent improvement and not a makeshift, that we would especially lay stress on.

EXPERIENCE IN TREATMENT OF PULMONARY TUBERCULOSIS IN INDIANS BY TUBERCULIN.

BY

MAJOR A. W. R. COCHRANE, M.B. (Lond.), F.R.C.S. (Eng.), I.M.S.,
Superintendent, King Edward VII Sanatorium, Bhowali,

AND

MAJOR C. A. SPRAWSON, M.D., M.R.C.P. (Lond.), I.M.S.,
Professor of Medicine, King George's Medical College, Lucknow.

In the last few years many books and articles both long and short have been written about treatment by tuberculin. The general consensus of opinion amongst tuberculosis officers, medical officers of Sanatoria and physicians of experience with tuberculin is that we have in tuberculin a valuable though by no means a direct remedy against tuberculosis. There are a few dissentients, but the strongest evidence is that those who have once tried tuberculin treatment systematically, do not give it up. A few quotations from the recent Annual Congress on Tuberculosis as reported in the British Medical Journal will be sufficient to illustrate this point. Professor Sims Woodhead stated "under proper conditions the exhibition of tuberculin exerts a favourable influence on the course of tuberculous disease."

Dr. Nathan Raw of Liverpool said that after treating over 1,000 cases he was convinced that tuberculin was a remedy of the greatest value.

Dr. White of the University of Pittsburg summed up his conclusions with "I can only say that I fully believe in tuberculin as an aid to treatment in tuberculous cases."

Dr. Amrein of Switzerland said tuberculin could not be a panacea, but combined with other methods of treatment it had proved itself a most valuable preparation.

It might be thought that a reasonable deduction could be made that tuberculin would be found of equal value in the treatment of pulmonary tuberculosis in Indians, and in the opinion of the authors this deduction is a correct one; but there exists amongst several medical men out here a feeling that the resistance of the Indian to this disease is so poor that no stimulus to his tissues is sufficient to make him overcome the tubercle bacillus once the lung has been attacked. This feeling is not unwidely spread, and though it is difficult to find its expression in print, we are able to quote here from a recently published clinical handbook; which states after a brief general account of tuberculin.

"The value of tuberculin for Indians has still to be proved, as their resisting power to phthisis is undetermined, and it is probably less than that of the Europeans, and tuberculin in India is still on its trial."

The opinion of Lt.-Col. Sir James Roberts, I.M.S., who has had experience of tuberculin administration when in charge of the Medical School at Indore, and who has been largely regarded as an authority on tuberculosis in India is still more pessimistic on the use of tuberculin in India. In a letter to one of us, from which he kindly allows us to quote, Sir James Roberts states :—"To imagine we had any specific remedy for tubercle of the lungs among Indians is I consider a mistake; it is of some assistance if a case be caught early but not much. That I have cured some such cases is true, when tubercle bacilli were found in the sputum and when no fever existed, but these cases were associated with open air treatment, etc., without these the tuberculin would have failed. ....I consider Indians more susceptible to tubercle than Europeans, and less resistant to the progress of an infection, especially in the lungs..........probably owing to the disease having been of less long standing in India. ....Once the lung is attacked the prognosis in Indians is very bad indeed; if caught early the hills, open air, etc. ......is their only chance......... I do not think that in India tuberculin injections that are not associated with other treatment are any good. The treatment of patients with commencing tubercle of the lung at a tuberculin dispensary in India I do not consider of any value."

We have quoted parts of this letter at length, because coming from such an authority as Sir James Roberts the opinions expressed are worthy of much consideration; but we are by no means in accord with these and it is to confute these and help to establish the value of tuberculin in Indians that this paper is written. Before passing on to our own evidence we would remark that Sir James Roberts' experiences were obtained mostly in a period when tuberculin treatment was not so well understood nor systematised as it now is, and that similarly disappointing results would now also be obtained in the treatment of pulmonary tuberculosis, were the system of dosage now employed not carried out.

Some evidences of the use of tuberculin in India have already been published. Chief amongst them is the paper by Dr. S. P. Shivdas of Bombay appearing in the "Journal of Vaccine Therapy" for May 1912. We will quote alone Dr. Shivdas' figures for pulmonary tuberculosis.

Number treated.	Completely satisfactory results.	Partly satisfactory results.	Unsatisfactory results.	Incomplete course.
53	8	10	18	17

If we translate these figures so far as possible into the form we have adopted for our own statistics they will read—

Number treated.	Disease arrested.	Improved.	Not improved. Died.
36	8	10	18

The general impression of the paper is that Dr. Shivdas is distinctly in favour of tuberculin as a means of treating tuberculosis even in out-patients. Dr. Shivdas writes :—"It (tuberculin) is indeed a most potent weapon and if used with all the necessary precautions......certainly proves of great value as a therapeutic measure."

A further account of Tuberculin in Bombay is given by Dr. N. F. Surveyor who in a paper read before the Bombay Medical and Physical Society, sums up his

experiences by favouring the administration of tuberculin to out-patients and considering it of great value.

Mr. G. C. Chatterji writing in the *Indian Medical Gazette* of November 1912 also favours the administration of tuberculin to out-patients, who formed the entire list of cases that he reports. His figures for pulmonary tuberculosis translated into the form we have adopted read thus :—

Number treated.	Disease arrested.	Improved.	Not improved.	Died.
27	7	6	3	11

Some of Mr. Chatterji's cases show an unusual increase in weight, but in reporting these increases, account is not taken of the season of the year which exercises an influence in the way we shall endeavour to show below.

The experiences of Captain Matson, I.M.S., and Sub-Assistant Surgeon Gajan Singh reported in the *Indian Medical Gazette* for April 1913 lead them to quite another conclusion as regards out-patients. Not many cases are recorded ; and after a few remarks on tuberculin generally it is stated, "It need hardly be said that tuberculin is most unsuitable for administration to out-patients." The cases reported, however, are in a country district of Burma and the patients seem to have had to come in long distances to the hospital. Out-patient tuberculin treatment is naturally only suitable for patients within easy access of the dispensary.

We (the authors) now wish to bring forward evidence to show :—

(1) That tuberculin is of value in the treatment of pulmonary tuberculosis in Indians.

(2) That tuberculin may with advantage be administered to Indian out-patients.

(*a*) In cases where it is unnecessary that the patient should leave his home or even his work.

(*b*) In some cases where the patient either cannot or will not come into the hospital.

Our experience has been derived from patients under different conditions. One of the authors is Superintendent of a Himalayan Sanatorium, where the patients can be kept in bed and exercise regulated by the physician : the other has charge of a tuberculosis hospital in the city of Lucknow, where some of the patients are kept in bed but the majority are treated as out-patients, some because, like those mentioned under 2(*a*), it appears to do them no harm to remain at home or at work, and others because they will not consent to stay in hospital.

It has appeared to us suitable to combine our experiences with tuberculin obtained under these different conditions and publish them in one paper. It is with much regret that we are unable to compare our results with a series of cases not so treated since so far as we know none such are available.

Before proceeding to give our own statistics it is necessary to describe how we have agreed—

(1) To classify our cases on first coming under treatment.

(2) Under what headings to classify our results.

(3) By what criteria we shall adjudge which of these results has been attained.

(4) What conditions we should demand from a case before it can be considered as having been under tuberculin treatment.

1. The classification of cases on admission is extremely difficult. To express a patient's condition in a brief formula is more difficult still ; but it is convenient to

attempt something of the sort, and although impossible to regard all the factors, the three chief ones may be so expressed. These factors are—

(*a*) The extent of the lesion. Here Turban's well-known classification is adopted.

(*b*) The activity of the lesion as shown by the presence or otherwise of fever. Fever is judged as present when the five minute oral temperature is at a minimum of 98° or a maximum of 99° in the 24 hours, an allowance of $\frac{2}{10}$ths of a degree being made for females. We have adopted the following :—

S_1 A patient with no fever.

S_2 Patient has fever after non-regulated exercise, but not after exercise regulated by the physician.

S_3 Patient is a febrile only when kept in bed.

S_4 Where the patient is febrile in bed with the maximum temperature not above 100·5° F.

S_5 When the patient is febrile in bed with a maximum temperature of over 100·5° F.

(*c*) The presence of tubercle bacilli in the sputum : represented by the letter T.

So that the case of a patient, who had dulness at the right apex extending to the second rib in front and the suprascapular region behind with bronchial breathing and rales on auscultation ; whose sputum contained tubercle bacilli ; and who had a daily rise of temperature except when absolutely confined to bed, would be expressed by the formula T_2 S_3 T.

This does not take into account such factors as the pulse rate, relation of weight to the patient's normal and capacity for work, but these, although all to be recorded, cannot be well expressed in a single formula.

2. In classifying our results we employ the following terms :—

Disease arrested,
Much improved,
Improved,
Not improved,
Died.

It is sometimes difficult to say whether a patient is improved or not : he may appear slightly improved under treatment and the physician may be aware that if the patient had not been under treatment he would be much worse ; but then, a few months after the patient leaves hospital apparently improved, it may be heard that he is dead. It seems fair to classify such a patient as "not improved" and at the same time to impose a time limit. If a patient dies within two months after cessation of treatment he will then be classified as "died" although not under treatment at the time.

Some patients appear to be about the same after as before treatment ; both these and those who are worse are classified as "not improved," to avoid having too many separate headings ; that is, assuming the patient survives two months after treatment and is not to be classified as "died."

3. It is not difficult to say that a patient is "not improved." It is when we wish to prove to others that a case is "improved" or "disease arrested" that something more objectively demonstrable and not so dependent upon the personal equa-

the sputum is the most objective sign and the most satisfactory basis for such a classification; but its adoption would mean the exclusion from our records of several cases of undoubted pulmonary tuberculosis, who have never shown tubercle bacilli. "Disappearance of physical signs" has been suggested as a criterion but is unsatisfactory, because physical signs that have once been marked though they may readily improve and lose their active character, in the majority of cases never entirely disappear. "Capacity for work" is also employed as a criterion of improvement by some, but is not an accurate method, and amongst Indians, many of whom do not hear the call to work with the same acuteness that the average European does, and others of whom must work for their living whether physically equal to it or not, the adoption of this standard is to be deprecated.

The estimation of longevity after treatment as a test is not yet practical for us to use owing to a long enough period not having elapsed. "Increase of weight" has been also suggested but though an increase of weight usually accompanies an improvement it does not always do so except to a slight extent, especially in out-patients who are doing their usual work. If these same patients are put to bed their weight usually increases more. Moreover in India on the plains it is not uncommon for the healthy man to lose weight in the hot weather and regain it in the cold, though sometimes the reverse happens.

We have taken the weight record books of the United Service Club in Lucknow wherein from 1865 to the present day numerous Europeans have recorded their weights at frequent intervals, and have selected two periods one from March to July, the other from March to October to compare the weights of the same individuals and note any alteration due to the hot weather.

For the March to July period 107 cases are noted; of these 72 decreased in weight and the average decrease was 6·06 lbs. The remaining 35 increased in weight, and the average increase was 4·87 lbs. So that a decrease is the rule: adding together the increases and the decreases the average for this period is a decrease of 2·48 lbs.

Taking the period March to October it is seen that most of this lost weight is regained in the three months following July: in this period 43 men decreased in weight and their average loss was 5·78 lbs.; whilst 41 increased in weight and their average gain was 5·74 lbs. Adding together the decreases and increases for the March to October period the average decrease is only 0·15 lbs.

We have no such figures for Indians, but judging from clinical experience in Lucknow we think that about the same would hold good for them. There are many Indians both in health and doing well under treatment for pulmonary tuberculosis who between April and July, allowance being made for their lighter clothing, lose about 5 lbs.: whilst others remain stationary or may gain in weight. Our clinical experience has taught us to be quite satisfied with an out-patient who during the hot weather can keep his weight stationary and look upon a loss amounting to 5 lbs. as in some cases not of serious import. Any loss above that amount we should regard as indicating that the patient is losing ground.

It follows therefore that "increase of weight" is not *per se* a good criterion for estimating improvement in the plains of India, although a factor of considerable value.

On consideration of the whole matter we are forced to rely upon the sum of the above factors and the general condition of the patient in estimating his improvement or otherwise, and this brings us back to the personal equation of the physician and to his innate sense of fairness. The term "arrested" includes cases who ex-

press themselves as feeling well and fit and who evidently have returned to their full health and vigour—they are able to do their day's work without undue tiredness and are able to withstand any extraordinary fatigue or exertion without any return of their symptoms. The presence of some physical signs in the lungs is not incompatible with this condition nor, in the opinion of one of us (A. C.), is the presence of tubercle bacilli in the much reduced sputum, if indeed they or the sputum are still present.—

4. Before admitting a case to be classified in the records we are now submitting we demand—

(*i*) That the patient shall have been under our treatment for at least three months.

(*ii*) That he shall have had at least 20 injections of some form of tuberculin in dispensary cases or 12 injections in Sanatorium cases. This is to exclude from our statistics all those who have left treatment after a short period, or who have been found after a few injections to be unsuitable subjects for tuberculin.

As we have set forth to show that tuberculin is of value in treatment not only in Indians but also in the plains of India at a dispensary with only a few beds at its disposal, we have kept separate those treated under Sanatorium regime from those not so—the third table shows our combined figures.

Sanatorium Figures.

	Arrested.	Much improved.	Improved.	Not improved.	Died.
21 T_1	17	3	1	...	...
8 T_2	3	2	...	3	...
26 T_3	8	8	6	4	...
Total ... 55	28	13	7	7	0
... S_1	...	...	...	...	...
18 S_2	16	2	...	...	...
11 S_3	6	2	2	1	...
18 S_4	5	7	3	3	...
8 S_5	1	2	2	3	...
55	28	13	7	7	0

Total 55 cases—Average duration of treatment 120 days, percentage of arrested disease =50, with 23·6% much improved, 78% showed tubercle bacilli at beginning of treatment, 58% showed tubercle bacilli at end of treatment reported on.

Arrested cases 28—of which 67·8% showed tubercle bacilli before treatment, 35·7% showed tubercle bacilli at end of treatment.

Much improved cases 13, of which 11 are still under treatment.

Not improved, 12·7%.

29 cases of T_1 and T_2 of which 69% are arrested.

Lucknow Dispensary Figures.

	Arrested.	Much improved.	Improved.	Not improved.	Died.
21 T_1	12	8	1	...	...
17 T_2	3	6	6	...	...
15 T_3	1	7	4	1	3
Total ... 53	16	21	11	2	3
3 S_1	3	...	...	...	...
2 S_2	...	1	1	...	...
12 S_3	6	4	2	...	...
25 S_4	7	11	6	1	...
11 S_5	...	5	2	1	3
53	16	21	11	2	3

Total 53 cases—average duration of treatment 154 days, percentage of arrested disease 30%, with 40% much improved, 64% showed tubercle bacilli at beginning of treatment, 41% showed tubercle bacilli at end of treatment reported on.

Arrested cases 16—of which 43·7% showed tubercle bacilli before treatment, of which *Nil* showed tubercle bacilli after treatment.

Much improved cases 21, of which 17 are still under treatment.

Not improved or died 9·4%.

38 cases of T_1 and T_2 of which over 39% are "arrested."

Combined Figures.

	Arrested.	Much improved.	Improved.	Not improved.	Died.
42 T_1	29	11	2	...	...
25 T_2	6	8	6	4	1
41 T_3	9	15	10	5	2
Total... 108	44	34	18	9	3
3 S_1	3	...	...	...	...
20 S_2	16	3	1	...	...
23 S_3	12	6	4	1	...
43 S_4	12	18	9	4	...
19 S_5	1	7	4	4	3
108	44	34	18	9	3

Total 108 cases—average length of treatment approximately 136 days. Arrested disease 40·7%, with 31·5% much improved. Not improved or died 11·11%.

Arrested cases 44—which showed 59% with tubercle bacilli before treatment which showed 22·7% with tubercle bacilli after treatment.

Much improved 34, of which 28 are still under treatment.

67 cases of $T_1.T_2$ of which 35 or 52·2% have been arrested.

46 „ „ $S_1.S_2.S_3$ of which 31 or 67·4% have been arrested.

We much regret the absence of any figures for Indians dealing with cases treated without tuberculin, but claim that a study of the figures given in this paper which are not selected in any way except that they are of cases in which tuberculin has been persisted with, upholds our contention in favour of treatment by Tuberculin, and incidentally that tuberculosis in Indians is in any way especially refractory to treatment owing to an alleged markedly low resistance to the disease. Moreover we are inclined to believe that less will be heard of this lower racial immunity when a fuller appreciation of the earliest diagnostic symptoms and signs becomes more general and consequently cases present themselves earlier for treatment. In the absence of tubercle bacilli in the sputum our diagnosis of tuberculosis has been made on the sum of the clinical evidence furnished by symptoms and signs combined with the result of the tuberculin reaction. With reference to this last test we prefer to use the subcutaneous injection and to rely on the result of one injection alone; further, in the case of a positive result, this is only interpreted as indicating active disease when backed by the clinical evidence.

We further claim that from a study of the figures for the dispensary treated cases our second contention, that tuberculin can be administered successfully to out-patients, is amply fulfilled and this even in febrile cases brought to the dispensary in dhoolies or in ekkas.

With regard to the administration of tuberculin we would emphasize two points:—

1. It is not every physician who should give tuberculin to his patients though they may need it.
2. It is not every case of pulmonary tuberculosis that should have tuberculin.

On the first point we have laid stress in our paper on the Organization of Anti-Tuberculosis Measures in India. A special training in tuberculin administration is necessary before it can be conscientiously undertaken, and for this reason the King George's Medical College will give each of its students a three months' course on tuberculosis. Secondly at the Lucknow Dispensary and the King's Sanatorium we have to some extent picked our cases: the majority (about 75 per cent.) receive tuberculin; but there are some cases who come to us with only a few days life left to them, and for these or for patients with continual high fever and especially for the emaciated, tuberculin is usually of no use. With regard to emaciation there may be truth in the idea that it is the subcutaneous tissues that are mostly concerned in immunisation, as when this tissue is greatly reduced no local reaction to tuberculin can be obtained. Other classes of cases for which Tuberculin is not generally suitable are—

(1) where the minimal daily temperature is over 99°;

(2) with a minimum resting pulse temperature of 110 per minute or over.

Apart from those that should not receive tuberculin, there are those who do not attend regularly through carelessness and a want of power of appreciation of the treatment. It is for this reason that we here limited our reported cases to those who have a definite number of injections.

As regard the tuberculin used one of us (C. A. S.) has chiefly used the series P. T. O., P. T. and T. A., as recommended by Camac Wilkinson, and in this connection would like to record his experience that the ratio of the strengths of P. T. to P. T. O. is about as 25 : 1 instead of the ratio 50 : 1 as reckoned by Wilkinson. The other of

us (A. C.) has chiefly used T. B. E., but also T. A., the latter of which appears to be nearly 10 times as strong as B. E. We do not however consider that the variety of tuberculin used is of importance.

We have confined our remarks to tuberculosis of the lungs, but at the dispensary numerous cases of tuberculous glands in the neck, mesentery and mediastinum present themselves for treatment. In these the treatment by tuberculin presents a simpler problem owing to the absence of irregular auto-inoculation from the seat of the disease :—in such cases it is permissible to use tuberculin after comparatively little training and yet with much benefit.

In conclusion we state that it is our considered opinion based on a fairly large clinical experience that in tuberculin we have a great aid in the treatment of Tuberculosis and that it would be a great calamity were the physician in the present state of medical science, to be deterred from making use of it in suitable cases in either in or out-patient practice.

Sanatorium figures (representing conditions at begining of treatment).

Arrested.	Much improved	Improved.	Not improved.	Died.
T_1 S_2	T_8 S_4 T	T_8 S_4 T	T_2 S_4	*Nil.*
T_1 S_2 $T_{''}$	T_2 S_5	T_8 S_5 T	T_8 S_5 T	
T_1 S_2	T_1 S_4 $T_{''}$	T_3 S_4 T	T_3 S_4 T	
T_1 S_3	T_1 S_2 T	T_1 5_3	T_2 S_3 T	
T_8 S_3 $T_{''}$	T_3 S_4 $T_{''}$	T_8 S_4 T	T_2 S_4 T	
T_1 S_2 $T_{''}$	T_8 S_4 T	T_3 S_3 T	T_3 S_5 T	
T_3 S_3 T	T_2 S_8 T	T_3 S_5 T	T_3 S_5 T	
T_1 S_2	T_8 S_4 T			
T_3 S_4 T	T_8 S_4 T			
T_2 S_4 T	T_8 S_3 T			
T_1 S_8	T_8 S_4 T			
T_3 S_2 $T_{''}$	T_8 S_6 T			
T_2 S_8 T	T_1 S_2 T			
T_1 S_4 $T_{''}$				
T_1 S_2				
T_1 S_2 T				
T_8 S_8 T				
T_1 S_2				
T_1 S_2				
T_1 S_2				
T_2 S_2 $T_{''}$				
T_1 S_2 T				
T_1 S_4 $T_{''}$				
T_3 S_5 $T_{''}$				
T_8 S_2 T				
T_1 S_2 T				
T_8 S_4 T				
T_1 S_2 $T_{''}$				

Figures of Lucknow Dispensary.

Arrested disease.	Much improved.	Improved.	Not improved.	Died.
$T_1\ S_4\ T_{''}$	$T_2\ S_3\ T$	$T_2\ S_4\ T$	$T_3\ S_5\ T$	$T_3\ S_5\ T$
$T_1\ S_4$	$T_3\ S_3\ T_{''}$	$T_2\ S_3$	$T_2\ S_4\ T$	$T_3\ S_5\ T$
$T_1\ S_4\ T_{''}$	$T_1\ S_4$	$T_3\ S_5\ T$		$T_2\ S_5\ T$
$T_2\ S_4\ T_{''}$	$T_3\ S_5\ T$	$T_3\ S_4\ T$		
$T_2\ S_3$	$T_3\ S_4\ T$	$T_2\ S_3\ T$		
$T_3\ S_4\ T_{''}$	$T_2\ S_3$	$T_3\ S_4\ T$		
$T_1\ S_3$	$T_2\ S_4\ T_{''}$	$T_2\ S_3$		
$T_1\ S_3$	$T_1\ S_4$	$T_3\ S_4\ T$		
$T_1\ S_4$	$T_3\ S_4\ T$	$T_1\ S_4$		
$T_2\ S_4$	$T_3\ S_4\ T$	$T_2\ S_4\ T$		
$T_1\ S_3$	$T_1\ S_3\ T$	$T_2\ S_5\ T$		
$T_1\ S_1$	$T_1\ S_4\ T_{''}$			
$T_1\ S_1$	$T_1\ S_2$			
$T_1\ S_3\ T_{''}$	$T_3\ S_4\ T$			
$T_1\ S_3\ T_{''}$	$T_1\ S_4$			
$T_1\ S_1\ T_{''}$	$T_2\ S_5\ T$			
	$T_3\ S_5\ T$			
	$T_2\ S_5\ T$			
	$T_1\ S_4$			
	$T_1\ S_5$			
	$T_2\ S_4\ T_{''}$			

$T_{''}$ represents disappearance of T. B. at time of making report.

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A PRELIMINARY ENQUIRY INTO THE PREVALENCE OF TUBERCULOSIS AMONGST BOMBAY CATTLE.

BY

MAJOR T. H. GLOSTER, M.B., D.P.H., I.M.S.,

Assistant to the Director, Bombay Bacteriological Laboratory.

A PRELIMINARY enquiry was carried out to determine to what extent tuberculosis occurs among cattle in Bombay.

The enquiry fell under two heads :—

(1) The result of the examination of carcasses of cattle at the Bandra slaughter-house.

(2) Examination of milk samples for tubercle bacilli.

At Bandra slaughter-house where, on an average, 150 cattle are slaughtered daily, an inspection of the dressed carcasses is carried out by a qualified Veterinary Inspector. The Inspector stated that during an experience extending over several years he had not seen a single carcase affected with gross tuberculous lesions. This result contrasts with a recent experience in Cawnpore where out of 2,000 cattle slaughtered last year about 3 per cent. were found to be affected with tuberculosis in varying degrees. I inspected about 50 carcasses at Bandra, and found none affected with tuberculosis. Several abnormal thoracic lymphatic glands were removed and sections were made at the Laboratory, but none showed any evidence of tuberculosis.

Examination of milk samples.—So far the examination has been practically limited to milks from single cows. The milk of each cow was collected in a sterile bottle, attention having been paid to the cleaning of the udder and the hands of the milker. The samples were either examined on arrival at the Laboratory or if taken in the evening were kept on ice till the following day.

Thirty cubic centimeters of each sample were centrifuged and a small portion of the sediment was spread on a slide and stained by the Ziehl-Neelsen method. The sediment was then well mixed with 2 cubic centimeters of the separated milk and injected subcutaneously into a guinea-pig. One hundred and one samples of milk were tested in this way. These comprised :—

2 mixed samples of buffalo's milk.
1 single buffalo's milk.
98 single cow's milk.

Of the 101 milks examined, 37 were from a large dairy under European supervision, 20 from small dairies owned by natives and 44 from privately owned cows whose milks were not exposed for sale.

In one microscopic specimen acid-fast bacilli, not however morphologically resembling tubercle bacilli, were seen. The result of the animal test was negative in every instance, not a single guinea-pig developing tuberculosis.

NOTES ON ASSESSMENT OF WATER RATES.

BY

MAJOR L. W. S. OLDHAM, R.E.,

Sanitary Engineer to Government, Central Provinces

SECTION I.

INTRODUCTORY.

THIS note deals with the assessment of water rates in connection with municipal water supplies in the Central Provinces.

A perusal of the rules for assessment of water rates shows at once, how widely the rates vary (1) in the basis of assessment, (2) in the amount of the rates levied, (3) in the incidence of taxation.

Owing to the entirely different basis of assessment adopted in the various municipalities, it is difficult to compare the rates; an attempt has however been made in the comparative tabular statement attached, to do this, as is explained in a later portion of this note.

The water rates are ordinarily of three kinds :—

(1) A general rate, payable, with the exemption of the poorest classes, by all householders living within reach of the water pipes.

(2) A special rate for private supplies. This is in some cases a separate inclusive rate; in others a rate paid in addition to the general water rate.

(3) Rates paid for water supplied on measurement.

SECTION II.

(1) BASIS OF ASSESSMENT.

The most general basis of assessment is the rental value of the house.

In some cases the water rate is a fixed percentage of the rental value. This is the case in connection with the water supplies of Nagpur Civil Station, Amraoti Town, Jubbulpur and Raipur.

In other cases the general water rate is on a sliding scale, varying with the rental value, *e.g.*, Nagpur City, Wardha, Khandwa, Amraoti Camp, Harda, Burhanpur, Seoni.

In the cases of Bhandara and Hinganghat, the general water rate is assessed on incomes of householders.

(2) PRIVATE WATER RATE.

Even more diverse are the methods of assessing private water rates.

The private connection rate is assessed according to a sliding scale, on rental values, in Nagpur City, Wardha, Harda, Khandwa, Seoni, Burhanpur.

In the following cases a private water rate in addition to the general rate is assessed according to a sliding scale on the size of pipe, or ferule used.

Nagpur Civil Station, Amraoti Camp, Amraoti City.

In Jubbulpur the water rate for a private pipe is a separate inclusive rate, assessed on size of pipe. In Raipur private water rates are assessed as follows :—

(*a*) The general water rate payable on rental value.

(*b*) An additional rate according to sliding scale, on size of pipe.

(*c*) An additional rate according to sliding scale on income.

In Bhandara private water rates are assessed according to a sliding scale on incomes.

In Hinganghat private water rates are assessed on the number of persons in a household at a *per capita* rate varying according to income. Additional *per capita* charges are made for domestic cattle.

To further complicate matters in this town, on incomes in excess of Rs. 6,000 the private water rate is assessed at a fixed percentage of the income.

(3) PAYMENT BY MEASUREMENT.

Most municipalities have a rule that allows of a meter being fixed, and payment by measurement exacted in certain cases. In two towns only, *i.e.*, in Nagpur and Jubbulpur is there any attempt to systematically meter private supplies. This matter is further dealt with later in this note.

SECTION III.

WATER RATES COMPARED.

In order to compare the incidence of taxation, statements have been prepared showing the rates paid in different towns.

Owing to the want of uniformity in the basis of taxation it is very difficult to effect this comparison. The figures given in the two statements attached are approximate only in many cases ; but for the purpose in view approximate figures are sufficient.

Since rental values form the most general basis of taxation this has been adopted in the statements. To reduce a tax assessed on income to terms of a tax assessed on rental value, the one has been taken as 10 % of the other for purposes of comparison in these tabular statements.

In Statement II the points that attract attention are the following :—

(1) The very low minimum in nearly all cases paid for private connections.

In every town in the Central Provinces provided with a water supply, economy of water is essential while in some towns especially in Berar and Nimar shortage of water is the normal condition each hot weather. In these conditions the number of private connections should not be unduly extended ; since the quantity of water used and wasted by a household drawing their water from a private tap, secluded from observation, is very largely in excess of the quantity of water drawn by a household who obtain their supply from a public standard.

STATEMENT NO. I.

General water rates in different towns of Central Provinces and Berar.

tal Value.	Nagpur City.	Nagpur Civil Station.	Seoni.	Wardha	Harda.	Khandwa.	Burhanpur.	Amraoti City.	Amraoti Civil Station.	Jubbulpur.	*Buldana.	Raipur.	Bhandara.†	Hinganghat.†	Rates under proposed rules.	REMARKS.
	Rs. A.	Rs. A.	Rs. A.	Rs. A.	Rs. A.	Rs. A.	Rs.	Rs. A.	Rs. A.	Rs.	Rs. A.	Rs. A.	Rs.	Rs.	Rs.	
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
2 ..	..	..	..	..	..	..	..	..		..	1 0	..	1	1	..	
4 ..	1 12	0 12	1 0	1 0	1 0	..	..	0 12		..	2 0	0 8	..	..	1	*Buldana Rental value is taken @ 10% of valuation of house.
6 ..	1 14	1 8	2 13	2 13	2 13	2 0	1	1 8		..	3 0	..	..	..	2	
8 ..	2 0	1 8	..	..	..	2 0	1	..		..	5 0	..	..	..	2	
0 ..	2 2	2 4	..	..	..	..	2	2 4		..	10 8	..	6	..	..	
2 ..	2 4	2 4	..	..	..	2 4	2	..		..	..	..	..	..	3	
4 ..	2 6	3 0	..	..	..	..	3	..		..	..	..	9	..	3	
6 ..	2 8	3 0	7 8	7 8	7 8	2 8	3	..		2	15 0	4 0	..	..	..	† *Bhandara* and *Hinganghat.*
108 ..	2 10	3 12	..	..	..	..	4	3 12		..	..	5 0	12	12	..	
120 ..	2 12	3 12	..	..	..	2 12	4	..		..	..	..	..	..	..	
32 ..	2 14	4 8	..	..	..	..	5	..		..	..	..	..	..	..	
44 ..	3 0	4 8	11 4	11 4	11 4	3 0	5	4 8		..	22 8	6 0	..	18	..	Rental value is taken @ 10% of Income.
56 ..	3 2	5 4	..	..	..	..	6	..		3	..	..	18	..	6	
68 ..	3 4	5 4	..	..	..	..	6	..	12	..	..	..	..	..	..	
80 ..	3 6	6 0	..	..	..	..	7	6 0		..	..	..	..	..	..	
92 ..	3 8	6 0	..	..	..	4 0	7	..		4	30 0	8 0	..	24	..	
16 ..	4 0	6 12	..	..	..	..	8	6 12		..	..	..	24	..	..	
40 ..	4 8	7 8	18 12	18 12	18 12	5 0	9	..		..	37 8	..	..	30	9	
64 ..	5 0	8 4	..	..	..	..	15	..		..	..	10 0	30		4% on rental value	
88 ..	5 8	9 0	..	..	..	..	..	9 0		..	45 0	..	..			
12 ..	6 0	9 12	..	..	..	..	15 Max.	..		6	..	12 0	36			
36 ..	6 8	10 8	..	..	..	..	..	10 8		..	..	..	..			
60 ..	7 0	11 4	28 2	28 2	28 2	7 8	..	..		..	60 0	..	42	36 Max		
84 ..	7 8	12 0	..	..	..	8 12	..	..		..	..	..	..			
08	8 0	12 12	..	..	..	..	..	..		..	..	..	42 Max.			
80 ..	9 8	15 0	..	..	..	12 0	..	15 0		..	75 0	..	..			
04 ..	10 0	15 12	..	..	..	..	..	..	36 over 720	10	..	21 0	..			
30 ..	15 0	18 12	..	..	..	12 0 Max.	..			..	90 0 Max.	100 0 Max.	..	..	36 Max.	
20 ..	15 0 Max.	40 0 Max.	48 0 Max.	48 0 Max.	48 0 Max.	..	..	15 0 Max.	60 Max.	..	..	..	..	..	..	

Value.	Nagpur City.	Nagpur Civil Station, ½″ pipe.	Seoni.	Wardha.	Harda.	Khandwa.	Burhanpur.	Amraoti City, ½″ pipe.	Amraoti Civil Station, ½″ pipe.	Jubbulpur, ½″ pipe.	Buldana.	Raipur,* ½″ pipe.	Bhandara.	Hinganghat.†	Type rules proposed.
%	Rs. A.	Rs. A.	Rs. A.	Rs. A.	Rs. A.	Rs.	Rs. A.	Rs. A.	Rs.	Rs.		Rs.	Rs.	Rs.	Rs.
..	6 0	7 0	6 0	7 0	7 0	6	1 8	2 0	..	..	Rs. 4 per annum for ½″ pipe in addition to General water rates (see Statement I.)	6	..	..	..
..	6 8	7 0	6 0	7 0	7 0	6	1 8	2 0	..	..		6+0-8	12	..	..
30 ..	7 0	7 0	7 0	8 0	8 0	7	3 0	2 12	..	..		6-8+1	..	7	..
..	7 8	8 8	8 0	9 0	9 0	8	6 0	3 8	..	..		8+1	..	..	..
16 ..	8 0	8 8	8 0	9 0	9 0	8	6 0	3 8	..	..		8+2	15	..	..
..	8 8	..	9 0	11 4	11 4	9	9 0	..	..	..		9+3	..	8	12
12 ..	9 0	9 4	9 0	13 8	13 8	9	9 0	4 4	..	..		9+3	..	..	8% on rental value.
..	9 8	..	10 8	..	..	10	12 0	..	..	..		10+4	..	..	
10 ..	10 0	10 0	12 0	18 0	18 0	10	12 0	5 0	..	..		10+4	..	..	
..	..	..	..	..	..	11	15 0	..	..	..		11+6	21	..	
..	11 0	10 12	15 0	22 8	22 8	11	15 0	5 12	..	..		11+6	..	..	
..	..	..	..	..	..	12	18 0	..	..	..		12+7	..	..	
8 ..	12 0	11 8	18 0	27 0	27 0	12	18 0	6 8	14	..		..	..	10	
..	..	..	..	..	..	14	21 0	..	..	..		12+7	..	..	
..	13 0	12 4	21 0	31 8	31 8	14	21 0	..	..	..		13+8	27	..	
..	..	..	..	..	..	16	24 0	..	..	24		13+8	..	..	
7 ..	14 0	13 0	24 0	36 0	36 0	16	24 0	8 0	..	..		14+9	..	..	
..	..	..	..	..	..	18	27 0	..	..	..		14+10	33	..	
..	..	14 8	30 0	45 0	45 0	20	30 0	9 8	..	..		16+12	..	..	
..	..	..	..	..	..	25	50 0	10 4	..	..		..	39	15	
8 ..	22 0	16 0	36 0	54 0	54 0	25	50 0	11 0	..	..		..	..	..	
..	..	..	..	..	..	25	..	11 12	..	..		18+15	..	..	
..	..	..	..	..	..	..	50 0 Max.	12 8	..	..		..	45	..	
..	..	..	..	..	..	30		13 4	..	..		..	..	..	
..	30 0	19 0	48 0	72 0	72 0	35	..	14 0	..	..		22+18	..	..	
..	..	..	..	..	..	35	..	14 12	..	..		..	50	..	
..	38 0	22 0	60 0	84 0	84 0	48	..	17 0	..	..		26+24	..	20	
..	40 0	22 12	63 0	84 0 Max.	84 0 Max.	48 Max.	..	17 12	38	..		..	60	..	
..	60 0	..	72 0 Max.	..	..	..	..	20 0 Max.	..	..		..	72	..	72 Max.
..	..	..	..	..	..	..	..	..	60 above 720.	..		..	84 Max.	..	..

REMARKS.

* Raipur.

In addition a rate on income is levied :—

½% below Rs. 2,000

1% above 2,000.

Maximum payable Rs. 100 per annum.

This is estimated as shown in Tables. Rental value of house @ 10% of income.

† Hinganghat.

In addition a rate of Re. 1 per annum on each horse, ox, cow, etc.

A private connection is in fact a luxury, delivering water at the consumer's premises and saving him all cost of carriage. This being so a rate of Re. 1 per mensem should be the absolute minimum for a private pipe of the smallest size in use in any waterworks system.

(2) Another point in connection with private connections is that the number of taps allowed should be limited in proportion to the water rate paid. For the minimum rate one tap only should be given, and a rule should be strictly enforced by which this tap is fixed in full view from a public road. Such a rule would facilitate inspection and the check of leaky fittings and other causes of waste.

SECTION IV.

SALE OF WATER BY MEASUREMENT.

The fixing of meters on private connections, and the sale of water by measurement is a question that is always before a waterworks administration. It is evident that anything like the universal metering of private supplies on an Indian water works is impossible. On the other hand, there are probably few water supplies where this system might not be considerably extended, and developed, with great advantage, in addition to the income, and also in the reduction of waste.

The attached statement gives figures showing the development of income by the extension of the use of meters at Nagpur in the last seven years. The figures speak for themselves.

Year.	Number of meters.	Income from sale of water.	Cost of meter system.			Remarks.
			Capital cost of meters.	Repairs and maintenance.	Meter rent realised.	
1	2	3	4	5	6	7
		Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	
1906-1907 ..	100	6,292 0 0		519 14 6	*Nil.*	
1907-1908 ..	114	5,573 0 0		490 11 0	*Nil.*	Meter rules revised, and meters taken over by Water Works Administration in 1908 in civil station & 1912 in city.
1908-1909 ..	118	9,725 10 0		1,275 12 0	478 10 0	
1909-1910 ..	141	10,904 6 5	5,261 15 11	1,357 14 5	866 6 5	
1910-1911 ..	164	15,112 3 11		939 3 6	944 8 9	
1911-1912 ..	184	20,240 1 10		1,024 0 6	1,234 8 2	
1912-1913 ..	214	33,836 12 0		1,381 4 8	1,689 2 0	

It may be noted that the improvement in results dated from the time that all meters were taken over by the waterworks administration, and a small workshop with appliances for testing, repairing and replacing meters out of order was instituted, with a separate establishment for inspecting, reading and maintaining the meter system.

Prior to this most of the meters were the property of the householders and this was the cause of endless dissension, while the income realised was most dis-

SECTION V.

EXTRACTS FROM PROPOSED TYPE SET OF RULES FOR NEW WATER WORKS SYSTEM.

1. Water rates shall be imposed on the letting value of every building within the limits of the municipality according to the following scale :—

General Water Rate.

When annual rental value of a house does not exceed Rs. 12. Free.

When annual rental value exceeds Rs. 12, a general water rate of Re. 1 per annum shall be paid on every Rs. 25 or portion of Rs. 25 of rental value subject to a maximum of Rs. 36 per annum.

Water Rates for Private Connections.

	Water Rate per annum.
	Rs.
When rental value does not exceed Rs. 150	12
When annual rental value is above Rs. 150	8% of rental value subject to a maximum of Rs. 72 per annum.

2. For private connections the number of taps will be limited as follows :—

Annual Water Rate.	Maximum No. of taps allowed.
12 ..	1
24 ..	3
36 and over ..	No limit.

Where the number of taps is limited to one this tap must be fixed in such a place as to be in full view from a public road.

3. No pipe larger than ¾" diameter will be used for a private supply unless the water is paid for by measurement, that is a meter is fixed and excess water used (*vide* Rule 4 below) is paid for according to the meter readings, *plus* usual metre rent.

4. If the Committee think that in any building or land, having a private supply more water than a quantity calculated at the rate of 3,000 gallons for every rupee paid as rate is used, a meter may, at the cost of the Committee, be fixed on such part of the communication pipe as the Committee think fit, and thereupon an additional rate for the quantity used in excess of that covered by the rate under Rule 1 shall be paid, the said additional rate being calculated at 3,000 gallons per rupee or any part thereof, which is not a multiple of 3,000.

Note.

The excess consumption shall be calculated and charged for separately for each quarter.

5. Every person on whose pipe a meter is fixed by the Committee, shall, in addition to the rate otherwise payable for the use of the water, pay the following rate for the cost of providing and maintaining the meters :—

If the size of the meter be	½" then	Rs.	6-0	per	annum.
	¾" ,,		7-8	,,	,,
	1" ,,	,,	9-0	,,	,,

If the size of the meter be	1¼″	then	Rs.	12	per annum.
„	1½″	„	„	15	„
„	2″	„	„	18	„
„	2½″	„	„	24	„
„	3″	„	„	30	„
„	4″	„	„	39	„
„	5″	„	„	48	„
„	6″	„	„	60	„
„	7″	„	„	72	„

(*a*) No persons, factories, gardens, police, jail, etc., who take water on payment by meter shall use the public standards.

NAGPUR CITY.

There shall be imposed on every building or land, situated within 200 yards of a street in which there is a Supply Main of the Committee, a water rate according to the following scale :—

	When there is a private supply. Rs. A. P.	When there is no private supply. Rs. A. P.
Where the annual rental value of such building or land is Rs. 6 or under	6 0 0	Exempt.
Where the annual rental value of such building or land exceeds Rs. 6, but does not exceed Rs. 12	6 8 0	Exempt.
Where the rental value of such building or land exceeds Rs. 12, but does not exceed Rs. 24	7 0 0	1 12 0
For every succeeding Rs. 12 or part thereof up to Rs. 192	0 8 0	0 2 0
For every succeeding Rs. 24 or part thereof up to Rs. 504	2 0 0	0
Above Rs. 504	60 0 0	15

Provided that in the case of any building with a private supply which is exclusively appropriated to public religious worship and which does not form part of, or is not attached to any dwelling-house or shop, or which is not used or occupied as a private dwelling-house or shop, a rate of Rs. 7 per annum shall be charged.

Every person, on whose pipe a meter is put by the Committee, shall, in addition to the rate otherwise payable for the use of the water, pay the following rate for the cost of providing and maintaining the meter :—

If the size of the meter be	½″	then	Rs.	6-0	per annum.
	¾″	„	„	7-8	„ „
	1″	„	„	9-0	„ „
	1¼″	„	„	12-0	„ „
	1½″	„	„	15-0	„ „
	2″	„	„	18-0	„ „
	2½″	„	„	24-0	„ „
	3″	„	„	30-0	„ „
	4″	„	„	39-0	„ „
	5″	„	„	48-0	„ „
	6″	„	„	60-0	„ „
	7″	„	„	72-0	„ „

NAGPUR CIVIL STATION.

Rules for the imposition and collection of water rate in the Civil Station, Nagpur.

For every occupied house yielding, or which if rented would yield a yearly rent of Rs. 24 and above, the owner shall pay annas twelve per annum on every Rs. 25 or portion of Rs. 25, provided that the maximum amount on any one house

shall not exceed Rs. 40, and that no such rate shall be imposed unless the house (or the land attached thereto) is within 200 yards of a street or road in which there is a Supply Main of the Municipal Committee.

The Civil Station Sub-Committee will supply water to owners of houses, shops or godowns, on the following terms :—

On the written application of any person, the Civil Station Sub-Committee will at their discretion, allow him to take water into their premises by laying ½, ¾, 1 or 1¼ inch pipe at a charge of Rs. 7, Rs. 14, Rs. 28 and 44 respectively, per annum, *plus* the usual water rate levied under Rule 1. The cost of laying pipes is to be borne by the applicant.

Notification No. 168, dated the 9th February 1907.

WARDHA.

A water rate shall be imposed on the annual letting value of every building according to the following scale :—

	Where there is a private water-supply.				Where there is no private water-supply.		
	Rs.	A.	P.		Rs.	A.	P.
Where such value is Rs. 12 or under	7	0	0	per annun			
Where such value is over Rs. 12 and does not exceed Rs. 24	8	0	0	„	1	0	0
Where such value is over Rs. 24 and does not exceed Rs. 48	9	0	0	„	0	1	3
Where such value is Rs. 48	0	3	0	per rupee.	0	1	3
With a maximum charge of	84	0	0		48	0	0

Explanation.—Building means one main house used for residence of a family or families and includes latrine, stable, kitchen, cattle-shed and out-houses for servants attached to the same and built on the same premises, but does not include granary or shop or any other building so complete as to form a place of separate residence.

HARDA.

A water rate shall be imposed on the annual letting value of every building according to the following scale :—

	Where there is a private water-supply.				Where there is no private water-supply.		
	Rs.	A.	P.		Rs.	A.	P.
Where such value is Rs. 12 or under .. .	7	0	0	per annum.	Exempt.		
Where such value is over Rs. 12 and does not exceed Rs. 24	8	0	0	„	1	0	0
Where such value is over Rs. 24 and does not exceed Rs. 48	9	0	0	„	0	1	3
Where such value is over Rs. 48	0	3	0	per rupee.	0	1	3
With a maximum charge of	84	0	0		48	0	0

Explanation.—Building means one main house used for residence of a family or families and includes latrine, stable, kitchen, cattle-shed and out-houses for servants attached to the same and built on the same premises, but does not include

granary or shop or any other building so complete as to form a place of separate residence.

KHANDWA.

A water-rate shall be imposed on the annual letting value of every building within the limits of the municipality of Khandwa according to the following scale :—

				Private supply.			Public supply.		
				Rs.	A.	P.	Rs.	A.	P.
Where the rental value of a house is Rs. 12 or under				6	0	0	Exempt.		
Where the rental value exceeds Rs. 12		But does not exceed Rs. 24	..	7	0	0	Do.		
Ditto	24	Ditto 48	..	8	0	0	2	0	0
Ditto	48	Ditto 72	..	9	0	0	2	4	0
Ditto	72	Ditto 96	..	10	0	0	2	8	0
Ditto	96	Ditto 120	..	11	0	0	2	12	0
Ditto	120	Ditto 144	..	12	0	0	3	0	0
Ditto	144	Ditto 168	..	14	0	0	3	8	0
Ditto	168	Ditto 192	..	16	0	0	4	0	0
Ditto	192	Ditto 216	..	18	0	0	4	8	0
Ditto	216	Ditto 240	..	20	0	0	5	0	0
Ditto	240	Ditto 300	..	25	0	0	6	4	0
Ditto	300	Ditto 360	..	30	0	0	7	8	0
Ditto	360	Ditto 420	..	35	0	0	8	12	0
Ditto	420 and above	..	..	48	0	0	12	0	0

Provided that no such rates shall be imposed in regard to the public supply unless the house or the land attached thereto is within 300 yards of the supply main of the Municipal Committee.

If the Committee has reason to believe that in any building enjoying a private supply more water than a supply calculated at the rate of 1,500 gallons for every rupee of water rate paid by the assessee is used a meter may, at the cost of the committee, be put to such part of the communication pipe as the Committee thinks fit and thereupon any water consumed over and above the quantity covered by the rate at 1,500 gallons per rupee or any part thereof shall be paid for at the same rate.

SEONI.

There shall be imposed a water-rate on the annual rental value of every building according to the following scale :—

	Where there is a private water-supply. Per annum.				Where there is no private water-supply. Per annum.			
	Rs.	A.	P.		Rs.	A.	P.	
Where such value is Rs. 12 or under ..	6	0	0		Exempt.			
Where such value is over Rs. 12 and does not exceed Rs. 24	7	0	0		1	0	0	
Where such value is over Rs. 24 and does not exceed Rs. 48	8	0	0		0	1	3	per rupee.
Where such value is over Rs. 48 and does not exceed Rs. 72	9	0	0		0	1	3	do.
Where such value is over Rs. 72 ..	0	2	0	per rupee.	0	1	3	do.
With a maximum charge of	72	0	0		48	0	0	

Provided that the Municipal Committee may in its discretion exempt the occupier of any particular building or of houses in any particular portion of the town or of houses situated more than 200 yards from a hydrant.

BURHANPUR.

A water-rate shall be imposed on the annual letting value of every building within the limits of the Municipality of Burhanpur according to the following scale :—

		Where there is a private water-supply. Rs.	Where there is no private water-supply. Rs.
Where such value is Rs. 12 or under ..	..	1½	Exempt.
Where such value is above Rs. 12	But does not exceed Rs. 24	3	
Do. 24	do. 48	6	1
Do. 48	do. 72	9	2
Do. 72	do. 96	12	3
Do. 96	do. 120	15	4
Do. 120	do. 144	18	5
Do. 144	do. 168	21	6
Do. 168	do. 192	24	7
Do. 192	do. 216	27	8
Do. 216	do. 240	30	9
Do. 240 and above		50	15

AMRAOTI CITY.

Every occupied house, shop, or godown yielding, or which, if rented, would yield, yearly rent of Rs. 12 and above shall pay 1 rupee and 8 annas per annum on every Rs. 25 or portion of Rs. 25 rent, provided that the maximum amount of assessment on any one house, shop, or godown shall not exceed Rs. 15.

(*a*) The above rates are reduced to half rates from 1st April 1912, under Secretariat letter No. 6571, dated the 5th July, 1905.

* * * * * *

The Managing Committee will supply water to owners or occupiers of houses on the following terms :—

(*a*) On the written application of any person the Managing Committee may, at their discretion, allow him to take water into his premises by laying half-an-inch and one-inch pipe at a charge of Rs. 2 and Rs. 4 per annum, *plus* the usual water-rate.

AMRAOTI CIVIL STATION.

Every occupied house, shop, or godown yielding, or which, if rented, would yield, a monthly rental of—

	Rs.	60 and above		shall	pay	Rs.	5	per mensem.
Between	,,	40 and	Rs. 59	,,	,,	,,	3	,,
,,	,,	0 ,,	,, 39	,,	,,	,,	1	,,

The Managing Committee will supply water to owners or occupiers of houses on the following terms :—

(*a*) On the written application of any person, the Managing Committee may, at their discretion, allow him to take water into his premises by laying half-an-inch and one-inch pipe at a charge of Rs. 2 and Rs. 4 per annum, *plus* the usual water-rate.

BULDANA.

Hyderabad Residency Order Notification.

The 16th August 1898, *No.* 274.

It is hereby notified that the Resident has been pleased to sanction under provisions of section 44, clause (5) of the Berar Municipal Law, the imposition of a water tax by the Buldana Municipal Committee upon buildings situated within the limits of the Buldana Municipality at the rates set forth below :—

1st class houses	valued at	Rs. 5,000	and above	Rs. 90	per annum.
2nd	do.	4,000	and up to	4,999	Rs. 75
3rd	do.	3,000	do.	3,999	„ 60
4th	do.	2,500	do.	2,999	45
5th	do.	2,000	do.	2,499	37½
6th	do.	1,500	do.	1,999	30
7th	do.	1,000	do.	1,499	22½
8th	do.	700	do.	999	15
9th	do.	500	do.	699	10½
10th	do.	300	do.	499	5
11th	do.	200	do.	299	3
12th	do.	100	do.	199	„ 2
13th	do.	50	do.	99	Re. 1
14th	do.	less than Rs. 50			*Nil.*

These rates will supersede those prescribed in Residency Orders Notification No. 20, dated the 28th January 1896, and will come into force, with effect from the 1st April 1899.

Note.—In addition the following rates are paid for private connection :—½" pipe Rs. 2 or Rs. 4 if total water tax is less than Rs. 25 per annum ; ¾" and 1" pipes Rs. 8.

By order,

(Sd.) C. H. A. HILL,

Secretary for Berar.

JUBBULPORE.

Class A.—Buildings or lands to which a private supply of water from the service pipes of the Committee has been laid on.

* * * * * *

3. In respect to buildings and lands which come under Class A, as defined above, water will be supplied to private consumers through their own connections and will be charged for either by the size of the pipe or by the quantity of water used as registered by a municipal meter.

Payment by bulk for water not required for domestic purposes

4. (*a*) Water required for manufactories, fountains, gardens, or for any purpose not in the opinion of the Committees strictly domestic, will only be supplied on condition of payment by bulk.

Water required for domestic use to be paid for according to the diameter of pipe or to the measurement of quantity.

(*b*) Water required for domestic use, including the watering of private gardens attached to residences may be paid for at the option of the consumer according to diameter of pipe or according to measurement of quantity ; provided that if the diameter of the pipe is less than half-an-inch, the Committee may require payment to be made according to diameter of pipe ; provided also that in cases where payment is made according to diameter

of pipe, if the Committee suspect that the consumption of water is excessive in proportion to the amount of water-rate paid, the Committee may, at its own expense, attach a meter and charge according to measurement.

Rates for pipe connection.

5. The following are the rates fixed at present for connections paying by diameter of pipe :—

	Rs.	A.	P.	
¼" pipe	0	8	0	per month.
	1	0	0	„
	2	0	0	„
	4	8	0	„
	7	0	0	„

Hire of meter.

6. Except in cases where the meter has been attached by the Committee under the second proviso to Rule 4 (*b*) the consumer shall pay for the hire of the meter at the following rates :—

Size and kind.	Hire per annum. (*a*)	Hire per half-year. (*b*)	Hire per quarter. (*c*)
	Rs.	Rs.	Rs.
½" Siemen's or other inferential meter or pass meter	5	3	2
¾" do. do. ..	6	4	2½
1" do. do. ..	10	6	3½
1¼" do. do. ..	11	7	4
1½" do. do. ..	12	7¼	4½
2" do. do. ..	17	9	5
3" do. do. ..	25	14	8
4" do. do. ..	30	18	10
5" do. do. ..	40	25	15
6" do. do. ..	50	30	18
⅜" Positive meter..	9	5½	3
½" do.	12½	7¾	4
¾" do.	17½	10¾	6
1" do.	22¾	14	8
1½" do.	34½	21½	11
2" do.	51¾	34	18
3" do.	84	53	27

(*a*) Charge for more than 6 months and up to 12 months.
(*b*) Charges for more than 3 months and up to 12 months.
(*c*) Charges for three months or less than that period.

Rate of water by meter.

7. The rate for water taken in bulk or measurement will be one rupee for every three thousand gallons. But the Committee may give a special rate to large consumers of municipal water.

The sliding scale sanctioned in General Committee's resolution No. 1, dated the 20th January 1894, is as under :—

3,000 Gallons per rupee when the quantity does not exceed 5 million gallons.
4,000 Gallons per rupee when it exceeds 5 and not 10 million gallons.
5,000 Gallons per rupee when it exceeds 10 and not 15 million gallons.
6,000 Gallons per rupee when it exceeds 15 million gallons.

Class B.—Buildings or lands to which a private supply of water from the service pipes of the Committee has not been laid on, but which are situated at a dis-

tance not exceeding 200 yards from a public standard, by measurement made along any street, road, lane, passage, path or open land accessible to the occupier of such building or land by which water is or may be carried.

8. In respect of building and lands which come within class B, as defined above, the rate payable shall be calculated at two rupees per centum on the annual assessed rental thereof.

RAIPUR TOWN.

3. The occupier of a house to which a private supply of water from service pipes of the Committee has not been laid on shall pay water-rate as follows :—

(i) For every occupied house yielding, or which, if rented, would yield, a yearly rent of not less than Rs. 15 but less than Rs. 25, annas 8 per annum.

(ii) For every occupied house yielding, or which, if rented, would yield, a yearly rent of Rs. 25 and above, Re. 1 per annum on every Rs. 25 or portion of Rs. 25.

4. For every occupied house to which a private supply of water from the service pipes of the Committee has been laid on, the occupiers shall pay water-rate as follows :—

A sum equivalent to what would be payable by an occupier under Rule 3, *plus*

One-half per cent. per annum on incomes up to Rs. 2,000 and one per cent. per annum on incomes above Rs. 2,000, *plus*

A fixed charge of Rs. 6, Rs. 12 or 24 per annum according as the pipe laid down is one of ½″, ¾″ or 1″ diameter:

Provided that except where Rule 6 is applicable, the rate shall not exceed Rs. 100 per annum.

Payment of the amount calculated as above entitles the occupier to have, free of further charge, a supply to the house of 2,400 gallons of water for every rupee paid. The occupier shall be liable to pay at the same rate for any water consumed over and above the quantity covered by the payment.

Provided that a person occupying more than one house shall be assessed for each house, separately, and shall pay for all the houses in his occupation on a rate calculated on the total rental and on his income.

RAIPUR CIVIL STATION.

10. The owner of a bungalow shall pay a minimum water-rate of Rs. 9 per cent., on the rental value thereof so long as it is occupied, provided that in no case shall the rate so levied exceed Rs. 100 per annum. Payment of the amount so calculated entitles the occupier to have free of further charge, a supply to the house of 2,400 gallons of water for every rupee paid. The occupier shall be liable to pay at the same rate for any water consumed over and above the quantity covered by the payment. The owner shall pay half the rate per cent., when the bungalow is unoccupied, irrespective of whether a private supply has been laid on to it or not.

BHANDARA.

5. For the purpose of the assessment of the general water-rate the occupiers of houses within the Municipality shall be divided into the following classes, and

the rate chargeable to each member of each class shall be as shown below against that class :—

			Rs.		
When the occupier himself or jointly with other persons constituting with him an undivided family enjoys an annual income not exceeding ..		..	75	*nil*	per annum.
Ditto	ditto	ditto	100	1	
Ditto	ditto	ditto	250	3	
Ditto	ditto	ditto	500	6	
Ditto	ditto	ditto	750	9	
Ditto	ditto	ditto	1,000	12	
Ditto	ditto	ditto	1,500	18	
Ditto	ditto	ditto	2,000	24	
Ditto	ditto	ditto	2,500	30	
Ditto	ditto	ditto	3,000	36	
Ditto	ditto	ditto over	3,000	42	

7. The Municipal Committee may supply water to premises owned or occupied by private persons, companies or public bodies or institutions subject to the payment of a special water rate according to the following scale :—

			Rs.	Rs.	
On an income not exceeding		..	250	6	per annum.
Ditto	ditto	..	500	9	
Ditto	ditto	..	750	12	
Ditto	ditto	..	1,000	15	
Ditto	ditto	..	1,500	21	
Ditto	ditto	..	2,000	27	
Ditto	ditto	..	2,500	33	
Ditto	ditto	..	3,000	39	
Ditto	ditto	..	4,000	45	
Ditto	ditto	..	5,000	50	
Ditto	ditto	..	6,000	60	"
Ditto	ditto	..	12,000	72	"
Ditto	above	..	12,000	84	"

In addition to these rates persons who are assessed on an income not exceeding Rs. 6,000 shall pay one rupee a year for each horse, pony, mule, ass, ox, cow, bullock, buffalo, camel or elephant kept on the premises for other than domestic purposes: Provided that in no case shall the rate exceed Rs. 84 per annum (except as provided in clause *g*) of Rule (1) of the rules for the management of the Bhandara Water Works.

HINGANGHAT.

5. For the purposes of the assessment of the general water-rate the occupiers of houses within the Municipality shall be divided into the following classes and the rate chargeable to each member of each class shall be shown below against that class :—

When the occupier himself or jointly with other persons constituting with him an undivided family enjoys an annual income not exceeding			.. Rs.	75	*nil.*
Ditto	ditto	ditto		100	1
Ditto	ditto	ditto		250	3
Ditto	ditto	ditto		500	6
Ditto	ditto	ditto		1,000	12
Ditto	ditto	ditto		1,500	18
Ditto	ditto	ditto		2,000	24
Ditto	ditto	ditto		2,500	30
Ditto	ditto	ditto above		2,500	36

7. (*g*) A water-rate shall be levied according to the following scale :-

When the occupying party himself or jointly with other persons constituting with himself an undivided family if a private person enjoys an income not exceeding .. .. Rs. 500				The amount payable shall be Rs. 1-4-0 per annum for each person above the age of 12 years residing on the premises, subject to a minimum charge of Rs. 7 per annum.				
	Rs.		Rs.		Rs.	a.	p.	
Ditto	exceeding 500	but not exceeding	1,000	Ditto	1	8	0	with minimum of Rs. 8
Ditto	1,000	„	2,000	Ditto	2	0	0	„ „ „ 10
Ditto	2,000	„	4,000	Ditto	3	0	0	„ „ „ 15
Ditto	4,000	„	6,000	Ditto	4	0	0	„ „ „ 20
Ditto	6,000		A sum equivalent to ½ per cent. on his estimated income.					

NOTES ON WATER WORKS AND DRAINAGE BYE-LAWS.

BY

MR. J. W. MADELEY, M.A., M.I.C.E.,

Special Engineer, Corporation of Madras.

Bye-laws and Act interdependent.

1. THE writer has prepared designs for the improvement of water-supply and drainage systems for the City of Madras which have practically amounted to new water-supply and new drainage systems throughout the City. To ensure that these systems should be properly worked, it was necessary to prepare bye-laws regulating them : but it was found that, before the bye-laws could be put into operation, the clauses in the Municipal Act required alteration to such an extent that complete sets of new clauses had to be prepared. It is probable that every authority, when for the first time constructing new water-supply and drainage works on up-to-date lines, will not only find it necessary to prepare a set of bye-laws, but will also find that the Acts under which the bye-laws are to be prepared require revision.

Public Health Act for India.

2. In order to ensure uniformity of practice in sanitary matters, the writer is of opinion that a Public Health Act for India somewhat like the English Public Health Acts would be of great value. It is not known if there is any intention on the part of the Government of India to put forward such a measure, but in view of the great advances that are now taking place in sanitation in this country, some such Act is highly desirable.

The Public Health Act of 1875 has proved to be of the greatest value as an instrument for advancing sanitation in England, and it is believed that a similar Act would have an equally beneficent effect in India. Any such Act should be sufficiently general to allow for local variations in conditions, but, as far as possible, it should extend to all Municipal authorities identical powers in regard to the making and enforcing bye-laws and regulations.

Legal opinion necessary.

3. To ensure that the clauses put forward are valid, they should be submitted to high legal authority. The writer knows of instances where it was found that an Act contained flaws so that its provisions could not be enforced and where in consequence there was considerable delay while the necessary amendments were made. If there were one Public Health Act for the whole of India, every authority would know exactly what were its powers.

4. It is difficult to decide what shall be the dividing line between the Act and the bye-laws. The writer has adopted the principle that the clauses of the Act shall state what is to be done, the President, the Standing Committee, or the Corporation to pass the necessary orders. The bye-laws are more of the nature of specifications describing how the work is to be carried out and, in most cases, the Engineer decides whether or not they have been complied with.

Dividing line between Act and Bye-laws.

5. The same reasons which make a single Public Health Act desirable, also hold good for standardisation of bye-laws. It appears to the writer highly important that sanitary works should be standardised so far as local variations in conditions permit. Water and drainage works are now being undertaken by a very large number of communities in India, and it will be of very great advantage, not only to inhabitants, but also to architects, engineers, builders, plumbers, and others, if a standard code of rules can be adopted.

Standard Bye-laws required to ensure uniformity of practice.

In England, difficulties arising from differences in the rules of sanitary authorities have caused a strong demand for standardisation. This has resulted in the formation of Committees representing all interested parties to draw up standard rules and regulations. Some such procedure might, with advantage, be adopted in India.

6. The following lists show the points dealt with by the writer in the clauses that he has proposed for the Madras City Municipal Act, and in the proposed bye-laws for water and drainage. In preparing the clauses of the Act, the writer has extracted some from the Bombay Municipal Act and English Public Health Acts with such modifications as appear desirable for Madras, and he has also prepared new clauses where required. The bye-laws are based on standard English practice with such modifications and additions as are necessary for Madras.

Example of subjects dealt with in Act and Bye-laws.

Water Works clauses for Municipal Act.

1. Provision of supply of drinking water by Corporation. 2. Fire hydrants to be provided. 3. Supply of water for domestic purposes. 4. President may in certain cases require owners to obtain private water-supply. 5. Making and renewing connections with Municipal water works. 6. President may take charge of private connections. 7. Power of President to alter position of connections. 8. Provisions as to storage cisterns and other fittings, etc., to be used for connections with water works. 9. Supply of water for other than domestic purposes. 10. Obligation of owner or occupier to give notice of waste of water. 11. Penalty for destroying valves, etc. Obligation to give notice of waste, etc. 12. Power of Corporation Engineer to enter houses to inspect, etc. 13. Where several houses supplied by one pipe, each to pay. 14. Penalty for allowing persons to use the Corporation water. 15. Penalty for taking the Corporation water without agreement. 16. Power to let meters, etc., for hire. 17. Power to ascertain quantity consumed by meter, and remove meters, etc. 18. Power to cut off water in certain cases. 19. Penalty for application of water contrary to agreement. 20. Penalty for extension or alteration of pipes. 21. Cutting off of supply to premises. 22. Fencing of supply channel. 23. Trespass on land where conduit runs or premises connected with supply. 24. Procedure if name and address of tres-

passer unknown. 25. Construction of water works. 26. Vesting of water works in Corporation. 27. Powers of Corporation in executing works without City. 28. Jurisdiction of Magistrate without City in respect of such works. 29. Power of President in respect of laying pipes. 30. Notice and compensation to owner of property affected. 31. Prohibition against damage to works. 32. Prohibition against opening or removal of lock, cock or pipe. 33. Power of Corporation to make bye-laws.

Water Works Bye-laws.

1. Operation of Bye-laws and Regulations. 2. Definitions. 3. Application for supply. 4. Private water-supply. 5. Connection to Corporation main. 6. Alteration or removal of consumers' pipes and fittings. 7. Repairs to pipes, fittings, etc. 8. Provisions relating to the prevention of waste, etc., of water. 9. Consumers' pipes and fittings. 10. Material of consumers' pipes. 11. General specification. 12. Lead pipes. 13. Cast iron pipes. 14. Accessibility of pipes, etc. 15. Wrought-iron and steel tubes. 16. Brass and copper tubes. 17. Consumers' fittings. 18. Taps and cocks. 19. Bath and lavatory fittings. 20. Ball taps (Croydon pattern). 21. Supply cisterns. 22. Flushing cisterns. 23. Use of automatic flushing apparatus, hoses, &c. 24. Hot-water apparatus. 25. Warning pipes. 26. Testing and stamping. 27. Method of laying consumers' pipes. 28. Premises not to be supplied through more than one supply pipe. 29. Separate supply pipe to every dwelling house. 30. Position of stop cock. 31. Taps for drinking water. 32. Consumers' outside taps or stand pipes. 33. Pumps drawing water direct from water-supply pipe. 34. Prohibited connections of consumers' pipes. 35. Certain supplies to be passed through meter. 36. Agreement for meter supplies. 37. Charges for water supplied by meter. 38. Water required for building purposes, &c. 39. Cattle troughs. 40. List of authorised plumbers. 41. Penalties. Schedule A: Application for a supply of water. Schedule B: Agreement for the supply of water by meter. Schedule C: Authorisation of plumbers.

DRAINAGE CLAUSES FOR MUNICIPAL ACT.

Municipal Drains.

1. Municipal drains to be under the control of the President. 2. Vesting of water-courses. 3. Drains to be constructed and kept in repair by the President. 4. Power to make drains. 5. Buildings, etc., not to be erected over drains without permission. 6. Alteration and discontinuance of drains. 7. Cleansing drains.

Drainage work of private streets and premises.

8. Power to connect drains of private streets with Municipal drains. 9. Power of owners and occupiers of premises to drain into Municipal drains. 10. Connections with Municipal drains not to be made except in conformity with clauses 8 and 9. 11. Rights of owners and occupiers of premises to carry drains through land belonging to other persons. 12. President may enforce drainage of undrained premises situate within a hundred and fifty feet of a Municipal drain. 13. President may enforce drainage of undrained premises not situate within a hundred and fifty feet of a Municipal drain. 14. Power of President to drain premises in combination.

15. President may close or limit the use of existing private drains. 16. Vesting and maintenance of drains for sole use of properties. 17. New buildings not to be erected without drains. 18. Excrementitious matter not to be passed into cesspools. 19. Obligation of owners of drains to allow use thereof, or joint ownership therein, to others. 20. How right of use or joint ownership of a drain may be obtained by a person other than the owner. 21. President may authorise a person other than the owner of a drain to use the same or declare him to be a joint owner thereof. 22. Sewage and rain-water drains to be distinct. 23. Drains not to pass beneath buildings. 24. Position of cesspools. 25. Right of Corporation to drains, etc., constructed, etc., at charge of Municipal fund on premises not belonging to the Corporation. 26. All drains and cesspools to be properly covered and ventilated. 27. Affixing of pipes for ventilation of drains, etc.

Disposal of sewage.

28. Appointment of places for emptying of drains and disposal of sewage. 29. Provision of means for disposal of sewage.

Water closets, Privies, Urinals, etc.

30. Construction of water-closets, privies, etc. 31. Water-closet and other accommodation in buildings newly erected or re-erected. 32. Where there is no such accommodation or the accommodation is insufficient or objectionable. 33. Power to require privy accommodation to be provided for factories, etc. 34. Power of President as to unhealthy privies. 35. Use of places for bathing or washing clothes or domestic utensils. 36. Public necessaries.

Inspection.

37. Power of entry to inspect and examine drains, etc., not belonging to the Corporation. 38. Power to open ground, etc., for purpose of such inspection and examination. 39. When the expenses of inspection and examination are to be paid by the President. 40. When the expenses of inspection and examination are to be paid by the owner. 41. President may require repairs, etc., to be made. 42. Costs of inspection and execution of work in certain cases.

General Provisions.

43. Prohibition of acts contravening the provisions of this division or done without sanction. 44. Prohibition of passing injurious matters into drains. 45. Conditions under which work may be done under this division for any person by the President. 46. President may execute certain works under this division without allowing option to persons concerned of executing the same. Expenses in such cases, by whom to be paid.

DRAINAGE BYE-LAWS.

General Provisions.

1. Operation of bye-laws. 2. Interpretation of terms and specification for materials. 3. Engineer to be judge of compliance with bye-laws.

Exclusion of Rain-water and silt.

4. Separate drains to be provided for foul water and rain-water. 5. Rain-water drains. 6. Rain-water pipes and gutters. 7. Inlets to drains to be above flood level.

Drainage of buildings by stoneware or iron pipes.

8. Rain-water to be provided. 9. Size of drain. 10. Gradients. 11. Drains to be straight. 12. Junctions and bends to be formed in manholes. 13. Materials. 14. Pipe. 15. Joints of drains. Excavations. 16. Bedding. 17. Jointing. 18. Drains to be water-tight. 19. Traps to drain inlets. 20. Traps and gullies. 21. Disconnecting trap. 22. Manholes, etc., to be water-tight. 23. Drain junctions. 24. Drains under buildings. 25. Protection of pipes beneath walls.

Ventilation of Drains.

26. Ventilating openings required. 27. Arrangements when disconnecting trap required. 28. Openings to be protected. 29. No bends or angles in pipes. 30. Diameter of pipes. 31. Soil pipes as ventilating pipes.

Waste Pipes.

32. Materials and sizes. Traps. 33. To discharge into the air over a gulley. 34. Supports.

Water-closets, latrines, urinals, slop-sinks and their proper accessories.

35. Position. 36. Construction. 37. Lighting, and ventilation. 38. Flushing cistern. 39. Automatic flushing apparatus. 40. Flushing pipe. 41. Water-closet receptacle. trap flushing arrangement. 42. No casing.

Soil pipes.

43. Position. Materials. Thickness and weight. 44. Supports. 45. Connections. 46. Diameter-Outlet.

Soil pipe, waste pipe and ventilating pipe connections.

47. Joints for lead and iron pipes. 48. Pipe and joints to be air-tight. 49. Connection of lead pipe with cast-iron pipe. 50. Connection of stoneware trap with lead pipe. 51. Connection of lead pipe with stoneware drain. 52. Connection of cast-iron pipe with stoneware drain. 53. Connection of stoneware trap with cast-iron soil pipe.

Ventilation of water-closet Traps.

54. To be ventilated into the open air. 55. Materials and supports.

Drainage of Privies, Ash-pits, etc.

56. Washings only to be conveyed to drain.

Open Drains.

57. Construction. 58. Grating. 59. Silt-Catcher and trap.

Maintenance of Drainage system.

60. Drainage work and appliances to be kept in proper repair.

Notices and Deposit of Plans.

61. Notice of intention to construct works. 62. Deposit of plans and sections. 63. Approval or disapproval of plans. 64. Commencement of work. 65. Unlawful commencement of work. 66. License to carry out private drainage. 67. Notice of covering up portions of works. 68. Notice of completion. 69. Connection with Municipal drain. 70. Deposit of money. 71. Inspection.

Penalties.

72. Penalties.

Power to pull down work.

73. Power to remove, alter or pull down work.

Application of bye-laws to existing drainage systems.

74. Extent of compliance with bye-laws.

Drainage works carried out by Government in the city of Madras.

75. Plans, estimates and descriptions to be submitted. 76. Government to carry out work by any agency they may select.

WATER-SUPPLY FOR SMALL COMMUNITIES AND MUNICIPALITIES.

BY

MR. G. W. DISNEY, M. INST. C.E.,

Sanitary Engineer to Government, Bihar and Orissa.

THE following Water Works are described in this note :—

	Gallons per day.	Population served.	Gallons provided for per head per day.
1. Supply from well with raised Reservoir and 400 ft. of distribution piping ...	1,000	100	10
2. Supply from a Tank pumped into a raised Reservoir and supplied with 1,000 ft. of distribution piping	3,000	1,000	3
3. Hinoo Water-Supply	12,000	750	
4. Chandpur	25,000	3,000	8
5. Jorhat	40,000	5,000	8
6. Hazaribagh Jail and Reformatory ...	55,000	2,200	25
7. Silchar	101,500	10,000	10
8. Narainganj	250 000	26,000	11·7

The question of water-supplies for small communities is one constantly recurring in the plains of India, and a narrative of these with which the author has been associated may be of interest. Beginning at the smaller end, the first (Drawing No. 1*) is for a water-supply for a School Hostel, to supply 100 persons with water from a covered in well, pumped by a double Kite Action Pump into a raised reservoir, and delivered by gravitation. It will be seen that the pump is provided in duplicate to avoid the risk of an interruption of the supply owing to the break-down of one of the pumps. The capital cost of this installation is estimated at Rs. 2,700, varying according to local conditions, or Rs. 27 per head of the numbers proposed to be served.

2. The next type is for a water-supply from a tank (Drawing No. 2), the water being pumped up by a double Action Kite Pump, provided in duplicate, delivered into a tank placed on the crest of the tank embankment, and distributed

* The drawings will be shown at the Conference.

by gravitation therefrom to standposts provided along a pipe line of 1,000 feet in length. In Bihar tanks suitable for this method of supply abound. The estimated capital cost, inclusive of fencing but exclusive of excavating charges, is Rs. 4,373 but must vary according to local conditions. For a supply for 1,000 persons at 3 gallons this comes to Rs. 4-6-0 per head, and the recurring expenditure, including maintenance and labour for working the pumps, to –/2/6 0/00 gallons. Oil engines have not been adapted for this type owing to the difficulty in this Province of getting trained drivers to work them.

3. The next installation described is that for the water-supply of Hinoo, the temporary settlement for the Indian clerks employed in the Ranchi Secretariat. Here the population to be served is estimated at 750, and the quantity of water for which provision is made is 12,000 gallons, the distribution pipes being capable of delivering this amount in 4 hours. The water is pumped up from a well, sunk in the sandy bed of a river, by means of 6″ × 4″ × 6″ Worthington Duplex Pump of 1·38 P.H.P., capable of delivering 1,800 gallons per hour, or 30 gallons per minute, against a head inclusive of suction and friction of 152 feet, driven by steam generated by vertical boilers. The water passes through 40 inch Jewell Pressure Filters placed alongside the Engine House, from thence to a raised Reservoir of 6,400 gallons capacity, the floor of which is some 50 feet above the Engine House, and therefrom delivered by gravity to the various standposts (Drawing No. 3). The capital cost of the work, inclusive of the well, was estimated at Rs. 20,369. This high cost is due to two facts (1) that it is proposed to extend the water-supply to another part of the station, and (2) the arrangements being of a temporary nature are designed for easy removal. The engines, boilers and filters are provided in duplicate. The work was constructed in 1913. The cost of delivery at present amounts to Rs. 1-1-0 per thousand gallons.

Chandpur.

4. The next installation described is at Chandpur, in Eastern Bengal, constructed in 1912. The waterworks were designed for a supply of 25,000 gallons per day to serve a population of 3,000. The water is pumped up from the Megna River by a Horizontal Worthington Duplex Pump of ·73 P.H.P. capable of delivering 25,000 gallons in 10 hours, or 45 gallons per minute against a total head inclusive of suction and friction of 58 feet, and supplied by steam by a 7 feet high by 3′ 0″ diameter boiler. Both pumps and boilers are provided in duplicate. The pumped water discharges into a 6,000 gallon steel tank raised on a platform 30′ in height, and from there gravitates to the distribution system through 50″ Jewell Pressure Filters, also provided in duplicate and so arranged that one filter can be washed with filtered water from the other. For particulars see Drawing No. 4. The capital cost of the work was Rs. 27,583, or say Rs. 8-6 per head of population.

Jorhat.

5. The water-supply for Jorhat in Assam was designed for a supply of 40,000 gallons in 8 hours, the water being pumped from a large tank into a Settling Tank of 5,000 gallons capacity by Worthington Low Lift Centrifugal Pumps, of 2·3 P.H.P., each capable of supplying 5,000 gallons per hour, or 83·3 gallons per minute, against a head, inclusive of suction and friction, of 36 feet. From the Settling Tank the water gravitates through an 8-foot diameter Jewell Gravity Filter to a clear water well, from which it is again pumped up to an Overhead Reservoir of 34,000 gallon capacity, raised on a staging 45 feet high, by High Lift 4″ three-stage Worthington Centrifugal

pumps of 2·3 P.H.P., capable of delivering 5,000 gallons per hour against a total head of 70 ft. The pumps are driven by $5\frac{1}{2}'' \times 4''$ High Speed Steam Engines in duplicate, the steam being generated by vertical cross tube boilers, 3′-3″ in diameter by 8 feet high. As the engines drive direct on a shafting from which the pumps are driven it is possible for either engine to drive any two pumps. The agitator shafting of the Jewell Filter is also driven from counter-shafting. From the raised reservoir the water is distributed by gravitation. The area supplied is very compact and the distribution system economical. The capital cost therefore, as estimated, probably indicates the smallest cost for which a pumping plant of this description could be installed. This was Rs. 62,243, or Rs. 14-4 per head of population provided for. For particulars see Drawing No. 5. The work is under construction.

Hazaribagh Jail and Reformatory.

6. The Hazaribagh Jail and Reformatory water-supply is for a daily supply of 55,000 gallons, the water being pumped into an elevated unfiltered water tank of 20,000 gallons capacity, erected on the roof of the Engine House, by means of two $6 \times 5\frac{3}{4} \times 6$ Low Lift and $7\frac{1}{2} \times 5 \times 6$ High Lift Worthington Duplex Pumps, each capable of raising 4,000 gallons per hour. The boilers, each 9′-6″ high × 3′-9″ diameter being also in duplicate. From the Settling Tank the water gravitates through a 10-foot diameter Jewell Gravity Filter into a Clear Water Reservoir of similar capacity, from which it is pumped into a raised Service Reservoir, also containing 20,000 gallons, and distributed therefrom by gravity. The wash water tank, into which filtered water from the rising main is supplied by a bye-pass, is of 5,000 gallons capacity, and is erected on a steel staging 30 feet in height. The general arrangement of the pumping and filtration station is shown in Drawing No. 6. The cost of the work, which is at present under construction, is estimated at Rs. 80,000 or Rs. 36-6-0 per head.

Silchar.

7. The Water Works for Silchar, in Assam, were designed for a population of some 10,000 persons, and were estimated to cost say Rs. 1,30,000, or Rs. 13 per head of population, the water being pumped up from the Barak River by means of Vertical Worthington Low Lift Pumps of 5·63 P.H.P., each capable of pumping 170 gallons per minute against a head, inclusive of suction and friction, of 53 feet, and delivered into a 30,000 gallons steel Settling Tank, from which it gravitates through a 12 feet diameter Jewell Gravity Filter, and is again pumped up to a 27,000-gallon Steel Reservoir on a 40′ staging, by a Vertical Worthington High Lift Pump, capable of delivering 170 gallons per minute against a total head of 56 feet. The P.H.P. of the pumps is 5·63; the Low Lift Pump is situated 25 feet below ground level to get within suction limits, and is coupled to the High Lift Pump at the top of the well at ground level. The two pumps are driven by Vertical Worthington Steam Engines supplied with steam from locomotive boilers. The engines and boilers are in duplicate. For particulars see Drawing No. 7.

8. The Water Works for Narainganj were designed for a supply of 250,000 gallons in 8 hours' working, but are actually affording over 300,000 gallons daily. These were constructed in 1908, the capital cost up to the end of 1912 amounting to Rs. 2,22,294, and the approximate population served 26,000, or say Rs. 8-5 per head, the cost of delivery being As. 1·4 per 1,000 gallons. The draw off amounting to 11·7 gallons per head daily. The water is pumped from

the Megna River by means of Worthington Triple Expansion Pumps of 21 P.H.P., provided in duplicate into a Settling Tank, from which it gravitates through a Jewell Gravity Filter, 17 feet in diameter, to a clear water well of 9,700 gallons capacity, from which it is again pumped into an Overhead Reservoir, and from there gravitates through the distribution system. The calculated discharge is 417 gallons per minute. Both High and Low Lift Pumps are on the same engine. Owing to the difficulty of financing the project only one engine was originally provided, and this worked continuously for over 4 years, when a duplicate one was erected.

A NEW MODULE.

BY

MR. C. F. WILKINS,

Under Secretary to Government, United Provinces, Irrigation Department, Allahabad.

DESCRIPTION.

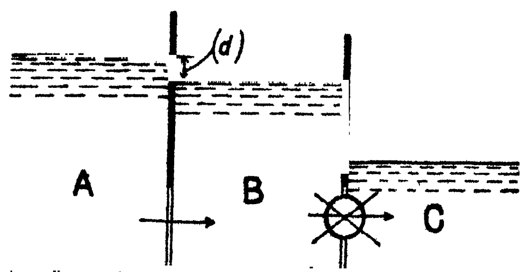
IN consequence of difficulties experienced in dealing with applications from cultivators complaining of inadequate supply from their outlets and with other complaints, the attention of the writer was drawn in 1909 to the necessity of a practical solution of the problem of the equitable distribution of a supply of water for irrigation.

Under the existing system of distribution two great defects were prominent: first, the ability of the cultivators to increase their share of the supply entering the head of a distributary, on the occurrence of drought, by simply cleaning out and widening their *guls*, and thus to disorganize the distribution at the very time when the water has reached its maximum value and its equitable distribution is most important; and second, the quite unnecessary waste of head that occurs in effecting the discharge through the bank of the distributary, the conserving of which might in many cases mean all the difference between flow and lift irrigation.

A sense of the extreme crudeness of the present system of distribution generally and a conviction that a simple and practical piece of apparatus could be devised to control a constant discharge to each outlet within a working range of water levels, and with but a small loss of head, led him to think about the matter.

A description of the manner in which the module which is the subject of this paper was approached, will best explain the principle on which it works.

Suppose A to be a source of supply the surface in which is liable to variations in level; and C a channel into which it is required to discharge a constant supply the surface in which is also liable to variations. Let B be an intermediate chamber, and let there be a fixed opening in the partition dividing B from A. Let (*d*) be the amount of head which it is considered necessary and permissible to sacrifice in effecting the discharge Q through the module. If now by any means the level of the surface in B can be kept at a height (*d*) below the level of the surface in A, then for all practical purposes the flow from A to B will be constant. This can be attained if we can place a valve in the partition between B and C so devised that it shall be operated only by variations in the difference of level between the surfaces in A and B from the fixed amount (*d*) and in such a manner that when this difference of level exceeds (*d*) the valve shall close and when it is in defect the valve shall open.



For suppose a steady régime of flow has been attained and the desired quantity Q cubic feet per second is passing into C. Now let the level of the surface in A rise. The difference of level having exceeded (*d*) the valve between B and C will immediately check the rate of flow from B to C and the level in B will rise until the difference of level is restored to its proper value. Suppose the level in C to suddenly fall. The rate of discharge from B to C will immediately increase with the result that the level in B will fall, the difference in level will increase, and the valve will operate to reduce the rate of flow from B to C and restore the difference to its proper value And similarly with other fluctuations. Thus a constant discharge Q will be maintained from A to C.

Accepting this as a satisfactory working principle, the problem was how to design the apparatus, and especially the valve, in a really practical manner. The present module is offered as the best solution.

Figures 3 and 4 show vertical and horizontal sections of an actual module to a scale of 1/5. This was constructed of galvanized and sheet iron and the results of tests carried out with it are given below.

The rigid system *abc* is the controller or regulator and is the only moving part. It consists of a horizontal circular plate *a* called the pressure plate, to which is attached by wires a vertical cylinder *c* open at both ends. The controller slides up and down along the vertical stem *e*. Surrounding the controller is a vertical cylinder *f* forming an outer casing. *g* is a partition plate with a circular opening in it through which the cylinder *c* passes as the controller rises. The region below the pressure plate *a* corresponds to the chamber A in the diagram. The region between the pressure plate *a* and the partition plate *g* corresponds to the chamber B. The space above the partition plate *g* corresponds to C. The annular area between *a* and *f* is the opening, fixed in extent, between A and B. The pressure head required to lift the controller and to keep it in equilibrium is the working head (*d*) on the annular area between *a* and *f*. After passing through this annular opening the stream divides into two portions, the one entering the cylinder *c* below its lower edge flowing upwards and spilling over its upper edge, the other flowing upwards and through the annular space between *c* and *g*. The two streams then unite and flow away through the off-take pipe. *a*, *b*, *c* and *g* in combination constitute the valve between the chambers B and C actuated alone by variations in pressure head from the fixed amount (*d*). Suppose a régime condition of flow has been attained, the controllers being in equilibrium under the difference of water pressure alone on the upper and lower surfaces of the pressure plate. If now the pressure below the pressure plate is increased by a rise in level of the supply in the distributary its equilibrium is disturbed and the controller is pushed up carrying with it the surface of the overflow at the top of the controller cylinder *c*. The result is an increase of the pressure on the upper surface of the pressure plate relatively to that on its under surface, and the movement will go on until a new position of equilibrium has been found, and then the working head on the annular area between *a* and *f* will have become restored to (*d*). On the other hand, should the depth of water above the partition plate *g* increase, the rate of discharge through the upper annular space between *c* and *g* becomes diminished with the result that the pressure on the upper surface of *a* increases and the controller sinks bringing down with it the surface of the overflow at the top of *C* until a new position of equilibrium has been found and the working head again restored to its proper value. And similarly with other variations of levels.

The controller may be made as light as the conditions of design and those to be fulfilled may require, and the loss of head can be reduced to an inch or even less. The amount of the effective head working upwards against the pressure plate can easily be observed at any time by means of a glass tube *i* to be attached for the moment (in this design) to the top of the pressure pipe shown in figure 3 passing through the pressure plate and reaching to the top of the cylinder *c* of the controller. It is measured by the difference of level between the surfaces of the liquid within and without the glass tube.

When the top of this cylinder contacts with the cross-bar *h* the controller has reached its highest position as the result of excessive pressure at the intake, and with any further rise in the distributary, excess flow is obtained through the module. This may be added to if necessary by inflow at the top of the upper chamber through a horizontal inlet which may be provided, as shown in figures 1 and 3. Thus ample escaping power may be provided through the module when full supply level in the distributary has been exceeded.

The rate of discharge is easily modified within certain limits by the addition of weights to the controller, or by otherwise altering its weight.

Small apertures may be provided in the pressure plate to assist in the scouring away of whatever may settle upon it and add weight.

The moving system being symmetrical about the vertical stem slowly turns round and so accurately takes up its equilibrium position.

The following table of observations gives the results of tests carried out with the module shown in the drawing and described above. The amount of head (*d*) lost in the module was only about one inch. The range of error may be taken to be from ·274 to ·281 cusec. The discharges were obtained by actual measurement in a box of the volume delivered (in all but the first experiment) in 1½ minutes.

The measurements in the columns under "Module" are the vertical distances from the upper edge of the upper chamber *j* to the outer and inner (not overflow) water surfaces respectively, and show the relative water-levels.

The box measurements given are the distances from the upper edge of the box to the surface of the water in it before and after the admission of the discharge from the module, and from these the volume has been calculated.

If it be desirable to reduce the length of the cylindrical adjunct *c* to the pressure plate it may be cut down as in figures 5 and 6, and allowed to butt close up against a fixed circular plate *k*. In this way the requisite restriction to the flow away from above the pressure plate necessary to the equilibrium of the controller may be obtained. By this means in certain cases, as in modules for minors and channels in which the depth of supply is small, the vertical length of the apparatus may be considerably diminished and the lower end of the cylinder *f* kept above bed-level.

This form of the apparatus has, however, yet to be tested. Should it prove successful considerable economy in cost of construction over the larger form may be possible.

Mr. W. B. Gordon in his note on Mr. R. G. Kennedy's Gauge Outlet Module said that to be perfect an irrigation module should meet the following requirements :—

(*a*) Steady automatic discharge of the volume allotted to the watercourse, notwithstanding variations of the head within fixed limits.

(*b*) Small loss of head.

(*c*) Freedom from derangement by silt or weeds.

(*d*) Portability.

Table of Observations.

The measurements were made by Mr. J. J. Ross, *sub-divisional officer. The time was taken by me with a good watch.*

Date.	Number of observation.	Module. Outer.	Module. Inner.	Measuring box 4′×4′. Before.	Measuring box 4′×4′. After.	Measuring box 4′×4′. Interval.	Discharge.	Remarks.
		Inches.	Inches	Ft. In.	Inches.	Minutes.	Cusec.	
The 28th January 1912 ..	1	..	..	1 9½	8½	1	A 0·29	This was only a preliminary observation to get an idea of the discharge.
Ditto ..	2	5	9½	1 9¼	2¼	1½	0·281	Free outfall.
Ditto ..	3	5	9¼	1 9	2	1½	0·281	Ditto.
Ditto ..	4	5	8½	1 10	3	1½	0·281	Ditto.
Ditto ..	5	4¾	8	1 10	3¼	1½	0·278	Ditto.
Ditto ..	6	4¾	8	1 10¼	3¼	1½	0·280	Ditto.
The 30th January 1912 ..	1	5½	9¼	1 8¾	2¾	1½	B 0·267	There was appreciable leakage between outflow pipe and measuring box which would account for this.
Ditto ..	2	2¾/1½	9	1 9½	2¾	1½	0·277	Varied from 2¾″ to 1½″ during the experiment.
Ditto ..	3	1½	8¾	1 10¼	3	1½	C 0·284*	
Ditto ..	4	1	7½	1 10	3	1½	0·280	A brick was put into the outflow pipe to head up the water.
Ditto ..	5	1⅝	6	1 9½	2½	1½	0·280	A brick was put into the outflow pipe to head up the water.
Ditto ..	6	2⅜	4	1 8½	2	1½	0·274	Outflow further restricted.
Ditto ..	7	¾/⅜	2⅜	1 9¾	3	1½	0·277	Ditto.
Ditto ..	8	⅞	8½	1 9¾	3½	1½	0·274	A certain amount of leakage.
The 3rd February 1912 ..	1	7	9½	1 10	3¼	1½	0·278	"Cultivator only just getting his full allotted discharge with newly opened distributary."
Ditto ..	2	½	9	1 10	3	1½	0·280	"Distributary nearly full."

**See* No. 8; ·284 seems too high and may be discarded.
Neglecting A, B and C, the mean of the remaining thirteen observations gives ·2787, say ·279 cusec.

(e) Absence of complicated mechanism.

(f) Provision, so far as is reasonably practicable, against derangement by outside interference.

(g) Means of being opened or closed by cultivator.

(h) Indication of working head or discharge.

(i) Increase in discharge when level of water in distributary rises above a certain height.

(j) Absence of any obstruction to the free passage of a reasonable share of silt from the distributary into the watercourse.

(k) Cheapness and durability.

The present module, properly designed for the discharge required, gives every promise that it will meet (a) and (b). As regards (c) there seems to be no danger whatever from silt. Weeds may get caught against the cross strips at the top of the controller pipe where the overflow takes place, but in moderate quantity here they do not affect the discharge as the controller merely takes a slightly lower position automatically compensating for the obstruction. An accumulation of weeds against the vertical wires at the opening below the controller pipe, when considerable, would cause loss of head at entry and would diminish the discharge. It may be possible to construct the controller without having these wires or rods.

Requirements (d), (e), (f), (g), (h), (i) and (j) all either are or can be met.

(k) The module shown in figures 1 to 4 was made by a local *mistri* for Rs. 30 and could be made for less, but of course it does not comply with (f) or (g) nor can it be described as very strong or durable. Cheapness together with durability necessarily implies a compromise between the two, and it remains to be seen what is the best practical shape the construction will take.

REPORT ON TESTS OF WILKINS'S MODULES.

BY

MR. S. A. BUNTING,

Assistant Engineer.

The testing arrangements consisted of—

(1) An outer tank A (figs. I and II), with a gauge B in it, whose zero was level with the partition plate, fed from the distributary through the groove and plank regulator C and sluice valve D, by means of which the level in it could be adjusted accurately to any desired amount below full supply level in the distributary.

(2) The module test box, divided by the fixed portion of the partition plate E, to which the bell-mouthed cylinder F is rigidly attached, into the lower and upper portions, G and H, respectively. Water is fed to G from tank A through the grating J (note that this grating was a mistake—an unrestricted passage is necessary), and so through the bell mouth up into the cylinder F, past the module into the top portion H, and thus through the wide passage K, which can be totally or partially closed by the hinged flap L, in order to raise or lower at will the level of water in H which is read on the gauge M.

(3) The discharge measuring tank, divided into rough water and smooth water portions N and P respectively by the baffle partition Q. Water passes from under the flap L into N down the sloping side, under Q into P, where it rises till its head above the centre of the orifice R is

sufficient to discharge it through that orifice, which is carefully turned in a brass plate 3/16" thick to be exactly 5·1" in diameter, and allowing only 1/20" thickness on the inner edge. This orifice is bevelled away on the outside at a steep angle. The level in P is read on the gauge S which is so graduated as to read directly in cusecs and tenths, and even hundredths of a cusec, with ease. This tank reads up to 1·75 cusecs only, but larger modules might be tested by putting in a larger orifice and another graduated discharge gauge. The module testing box is capable of taking a module of 2½ cusecs discharge and 1·75' range.

The comparatively small orifice working under a big head is the only satisfactory method of reading these discharges, emphasizing as it does very small differences of discharge by quite appreciable differences of head, easily read because the surface is quiescent, unlike any notch or weir or direct cubic measurement arrangement. But to attain our purpose in this instance a site was required with a difference of 8 feet at least between canal bed level and the bed level of the drain which carries the water off.

(4) The actual controller itself sliding on the rod T, which is graduated as a gauge to read the level of water flowing over the upper edge of the controller cylinder. The controller consists of the cylinder U attached by rods V to the pressure plate W. The size of the partition plate orifice can be altered by attaching annular pieces X of different sizes to the fixed partition plate E. The stem T has two nuts, Y and Z, that clamp to it, as end stops, to prevent the controller rising too high or falling too low.

The discharge of a Wilkins's module varies directly as the annular area between the edge of its pressure plate and the surrounding cylinder F, and as the square root of the weight of the controller. Its range is practically equal to the length of the controller cylinder minus the depth of water in the discharge pipe when the latter has a free outfall. To make up modules of varying discharges, within limits, and the same range then it is only necessary either to change the size of the annular space between the cylinder and pressure plate or to change the weight of the controller or both. Reducing the diameter of the pressure plate or increasing the diameter of the fixed cylinder increases the discharge without loss of working head, while weighting the controller increases the discharge with waste of working head.

In these trials both methods were used. The inside diameter of the cylinder F being $21\frac{9}{32}$" its cross sectional area was 2·470 square feet. Four pressure plates were used, $18\frac{5}{8}$", $19\frac{1}{8}$", $19\frac{5}{8}$" and $20\frac{1}{4}$" in diameter, and 1·892 square feet, 1·995 square feet, 2·101 square feet, and 2·2365 square feet in area, respectively. The annular areas between the cylinder and these plates are ·578 square feet, ·475 square feet, ·369 square feet, and ·2335 square feet. Reduced by the coefficient of contraction ·62, these annular areas become ·358, ·294, ·229, and ·145. This factor ·62 is probably too small as contraction is suppressed on the outside. If the weight of the controller in air be Wlb. its weight in water will be ·87Wlb. (presuming it is all steel), which, distributed over the area of the pressure plate, A square feet, $= \cdot 87\frac{W}{A}$lb. per square foot = a head of water of $\cdot 87\frac{W}{A} \times \frac{1}{62\cdot 5}$ feet $= \cdot 01392\,\frac{W}{A}$ feet.

The discharge = contracted annular area $\times\ 8\sqrt{\cdot 01392\frac{W}{A}} = \cdot 9438 \times$ contracted annular area $\times \sqrt{\frac{W}{A}}$.

For the $18\frac{5}{8}''$ pressure plate the discharge should equal $\cdot 2456\sqrt{W}$ cusec.
For the $19\frac{1}{8}''$ pressure plate the discharge should equal $\cdot 1964\sqrt{W}$ cusec.
For the $19\frac{5}{8}''$ pressure plate the discharge should equal $\cdot 1491\sqrt{W}$ cusec.
For the $20\frac{1}{4}''$ pressure plate the discharge should equal $\cdot 0915\sqrt{W}$ cusec.

Next, unfortunately lead weights were used instead of steel ones. One lb. of lead weighs ·912 lb. in water, and is therefore equivalent to $\frac{\cdot 91}{\cdot 87}$ = 1·05 lb. of iron. The part of " W " then which consists of lead must be increased in the ratio $\frac{105}{100}$.

Two controller cylinders were used, one $1'\ 10\frac{1}{16}''$ long for the 1·6′ range, the other $1'4\frac{1}{8}''$ long for the 1′ range. Both of them had an inside diameter of 15″ and an outside diameter of $15\frac{3}{32}''$. These are only approximate measurements as the material was thin and liable to slight distortion from true circular form. The distance between the lower edge of the controller cylinder and the pressure plate was made capable of adjustment by threading the attaching rods and fixing the pressure plate between two nuts on each of these threaded rods. Actually change was not considered necessary, and a standard distance of $3\frac{1}{2}''$ was maintained.

Five detachable annular plates were made for the partition plate, the diameters of the orifices in them being $15\frac{3}{8}''$, $15\frac{9}{16}''$, $15\frac{3}{4}''$, $15\frac{15}{16}''$ and $16\frac{1}{4}''$, both the last two being about $\frac{1}{32}''$ larger than their nominal dimensions. The contracted annular areas between the outside of the controller cylinder and the edge of the orifice were (using coefficient of contraction ·62, though again this is too small as contraction is suppressed on the inside) ·0290, ·0486, ·0684, ·0919 and ·1537, respectively. These multiplied by $8 \times \sqrt{\text{stem gauge—inner gauge}}$ should give the discharge through this orifice. The constants are therefore ·232, ·3888, ·5472, ·7354 and 1·2296 respectively. It is required in each case to have a partition plate orifice of such a size that even with the maximum difference between the stem gauge and the inner gauge as head (practically equal to the range of the module) the annular space between the controller cylinder and partition plate shall be not large enough to carry the full discharge. In practice the sizes of the partition plate orifices were determined by trial and error. In the following tables of readings the theoretical discharges between the controller cylinder and the partition plate are given and the remaining discharges assumed to fall over the controller cylinder edge.

Tests of modules made on 15*th and* 16*th June* 1913.

(1) Short controller, $20\frac{1}{4}''$ pressure plate, $15\frac{3}{8}''$ partition plate orifice, W = 21 lb.; therefore theoretical discharge is ·4194 cusec.

Gauges.			Observed discharges.	Theoretical portion of discharge between controller and partition plate.	Observed overflow depth over top edge of controller.
B.	T.	M.	Cusec.	Cusec.	
·38	·24	·1	·49	·086	$\frac{3}{4}$ inch.
·50	·34	·1	·51	·1136	$\frac{1}{8}$,,
1·47	1·33	·68	·49	·187	$\frac{5}{8}$,,
1·45	1·27	·96	·49	·129	$\frac{3}{4}$,,
1·46	1·29	1·24	·495	·0519	$\frac{7}{8}$,,
1·46	1·30	1·28	·495	·0328	$\frac{1}{4}$,,

***Remarks.*—Partition plate aperture about right. A good module for the half cusec.**

(2) Long controller, $20\frac{1}{4}''$ pressure plate, $15\frac{5}{8}''$ partition plate orifice, W = 18 lb. therefore theoretical discharge = ·3883 cusec.

Gauges. B.	T.	M.	Observed discharges.	Theoretical portion of discharge between controller and partition plate.	Observed overflow depth over upper edge of controller.
·85	·74	·1	·47	·1856	$\frac{1}{8}$ inch.
1·72	1·60	·1	·475	·2841	$\frac{1}{8}$,,
1·78	1·65	·69	·47	·2273	$\frac{1}{4}$,,
1·79	1·65	1·06	·46	·1782	
1·73	1·59	1·55	·47	·0464	
1·72	1·59	1·58	·46	·0232	

(3) Long controller, $20\frac{1}{4}''$ pressure plate, $15\frac{5}{8}''$ partition plate orifice, weight of controller 18 lb., added lead weights 14 lb. equivalent to 14·7 lb. iron ; therefore W = 32·7 lb. and the theoretical discharge = ·5232 cusec.

Gauges. B.	T.	M.	Observed discharges.	Theoretical portion of discharge between controller and partition plate.	Observed overflow depth over upper edge of controller.
1·05	·82	·75	·58	·06137	1"
1·05	·82	·1	·58	·1968	$\frac{5}{8}''$
·57	·35	·1	·54	·116	$\frac{3}{4}''$
1·87	1·65	·1	·56	·2888	$\frac{5}{8}''$
1·94	1·71	1·70	·56	*Nil.*	Submerged.

(4) Long controller, $19\frac{5}{8}''$ pressure plate, $15\frac{5}{8}$ partition plate orifice, W = 17·2 lb. and theoretical discharge = ·6183 cusec.

Gauges. B.	T.	M.	Observed discharges.	Theoretical portion of discharge between controller and partition plate.
·46	·33	·19	·61	·0868
1·16	1·02	·20	·65	·2101
1·85	1·72	·20	·66	·286
1·95	1·84	·21	·68	·2962
1·96	1·82	1·2	·65	·1827
1·93	1·77	1·55	·6675	·1088
1·93	1·77	1·77	·66	*Nil.*

(5) Long controller, 19⅝″ pressure plate, 15⅝″ partition plate orifice, weight of controller 17·2 lb., added lead weights 12·8 lb., equal to 13·44 lb. iron weights; therefore W=30·64 lb. and the theoretical discharge is ·8253 cusec.

Gauges			Observed discharges.	Theoretical portion of discharge between controller and partition plate.	Observed overflow depth over upper edge of controller.
B.	T.	M.			
0·65	0·34	0·21	·80	·08363	....
1·26	1·01	0·21	·85	·2075	....
*2·15	1·86	0·24	·86	·953	1″
†0·65	0·33	0·21	·795	3037	....
2·12	1·81	1·31	·88	1641	1¼″
2·12	1·83	1·78	·88	·05188	....

* Limit very nearly reached for this partition plate. It might be made 15½″.
† Reduction may be due to excessive overflow.

(6) Long controller, 19⅛″ pressure plate, 15¾″ partition plate orifice, W=17 lb. and the theoretical discharge is ·8099 cusec.

Gauges.			Observed discharges.	Theoretical portion of discharge between controller and partition plate.	Observed overflow depth over upper edge of controller.
B.	T.	M.			
1·6	1·35	·1	·85	·6118	....
1·47	1·03	1·03	·88	*Nil.*	....
1·92	1·57	·92	·86	·4412	....
1·91	1·54	·89	·84	·4412	....

Remarks.—Partition plate aperture a little too large.

(7) Long controller, 19⅛″ pressure plate, 5 9/16″ partition plate opening, W=17 lb. Theoretical discharge=·8099 cusec.

Gauges.			Observed discharge.	Theoretical discharge between controller and partition plate.
B.	T.	M.		
1·85	1·61	·22	·85	·4583
1·83	1·66	·71	·85	·3789
1·81	1·67	1·27	·88	·2458
1·81	1·59	1·4	·90	·1695
1·82	1·59	1·59	·87	....
1·22	1·03	·39	·86	·3110
1·23	1·06	·22	·87	·3563
1·1	0·81	·7	·89	·1290
0·49	·34	·21	·83	·1402

(8) Long controller, $19\frac{1}{8}''$ pressure plate, $15\frac{9}{16}''$ partition plate opening. Weight of controller 17 lb., added lead weights 11·9 lb. equivalent to 12·495 lb. iron. W=29·495 lb.; therefore theoretical discharge is 1·066 cusecs.

Gauges.			Observed discharge.	Theoretical discharge between controller and partition plate.
B.	T.	M.		
·64	·33	·26	1·06	·1029
1·54	1·25	·26	1·11	·3868
1·45	1·08	1·06	1·12·	·05498
2·0	1·59	1·12	1·17	·2665
2·02	1·67	1·04	1·17	·3085
2·13	1·83	·28	1·21	·4840
2·01	1·79	·26	1·14	·4809
2·02	1·69	·62	1·11	·4022
2·04	1·69	1·66	1·15	·0673

(9) Long controller, $18\frac{5}{8}''$ pressure plate, $15\frac{15}{16}''$ partition plate opening. W=17 lb.; therefore theoretical discharge=1·013 cusecs.

Gauges.			Observed discharge.	Theoretical discharge between controller and partition plate.
B.	T.	M.		
·53	·31	·26	1·06	·1645
·7	·51	·27	1·13	·3603
1·35	1·18	·27	1·09	·7015
*1·85	1·68	·27	1·10	·8732
1·95	1·81	1·13	1·08	·605
1·95	1·78	1·4	1·17	·4533
2·0	1·81	1·82	1·13	*Nil.*

* Limit of range reached with this arrangement, water only slightly overtopping the controller cylinder.

(10) Short controller, $18\frac{5}{8}''$ pressure plate, $16\frac{1}{2}''$ partition plate opening, W=21·3 lb.; therefore theoretical discharge=1·134 cusecs.

Gauges.			Observed discharge.	Theoretical discharge between controller and partition plate.	Overflow over upper edge of controller.
B.	T.	M.			
·59	·33	·27	1·16	·3012	Submerged practically.
*1·10	·87	·27	1·2	·9524	*Nil.*
1·65	1·31	1·15	1·18	·4918	1″

* Overflow a minimum.

Remarks.—Partition plate orifice too big for whole range.

(11) Short controller, $18\frac{5}{8}''$ pressure plate, $15\frac{15}{16}''$ partition plate orifice, W = 21 lb. Theoretical discharge = 1·126 cusecs.

Gauges.			Observed discharge.	Theoretical discharge between controller and partition plate.	Overflow over upper edge of controller.
B.	T.	M.			
·65	·30	·27	1·18	·1274	Submerged practically.
1·50	1·26	·3	1·24*	·7205	About 1".
1·55	1·36	·35	1·20	·7390	„ 1".
1·5	1·23	1·06	1·19	·3032	Submerged.

* The reading went down immediately after this was taken. A good 1·2 cusec module.

(12) Long controller, $18\frac{5}{8}''$ pressure plate, $15\frac{15}{16}''$ partition plate orifice, weight of controller 17 lb., added lead weights 9·7 lb. equivalent to 10·185 lb. iron ; therefore W = 27·185 lb. and theoretical discharge = 1·281 cusecs.

Gauges.			Observed discharge.	Theoretical discharge between controller and partition plate.
B.	T.	M.		
2·1	1·83	·3	1·39	·9095
1·92	1·56	1·6	1·35	*Nil.*
2·06	1·70	1·69	1·39	*Nil.*
2·19	1·79	1·8	1·40	*Nil.*
1·52	1·19	·3	1·36	·6938
1·5	1·18	·32	1·35	·6820
1·36	·98	·95	1·40	·1274
1·04	·65	·57	1·39	·2080

(13) Short controller, $18\frac{5}{8}''$ pressure plate, $16\frac{1}{2}''$ partition plate orifice, weight of controller 21·3, added lead weights 18·3 equivalent to 19·215 lb. iron ; therefore W = 40·515 lb. and theoretical discharge = 1·564 cusecs.

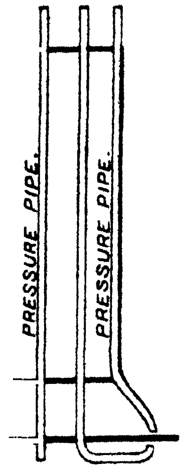
Gauges.			Observed discharge.	Theoretical discharge between controller and partition plate.	Overflow over upper edge of controller submerged.
B.	T.	M.	*		
*1·91	1·22	·4	1·62	1·113	¾" to 1"
1·80	1·16	·95	1·65	·5634	....

Remarks.—Disturbed water and turmoil, *i.e.*, diameter of controller cylinder not sufficient for this discharge.

* The inlet was found to be choked with leaves ; it was cleared before the next observation.

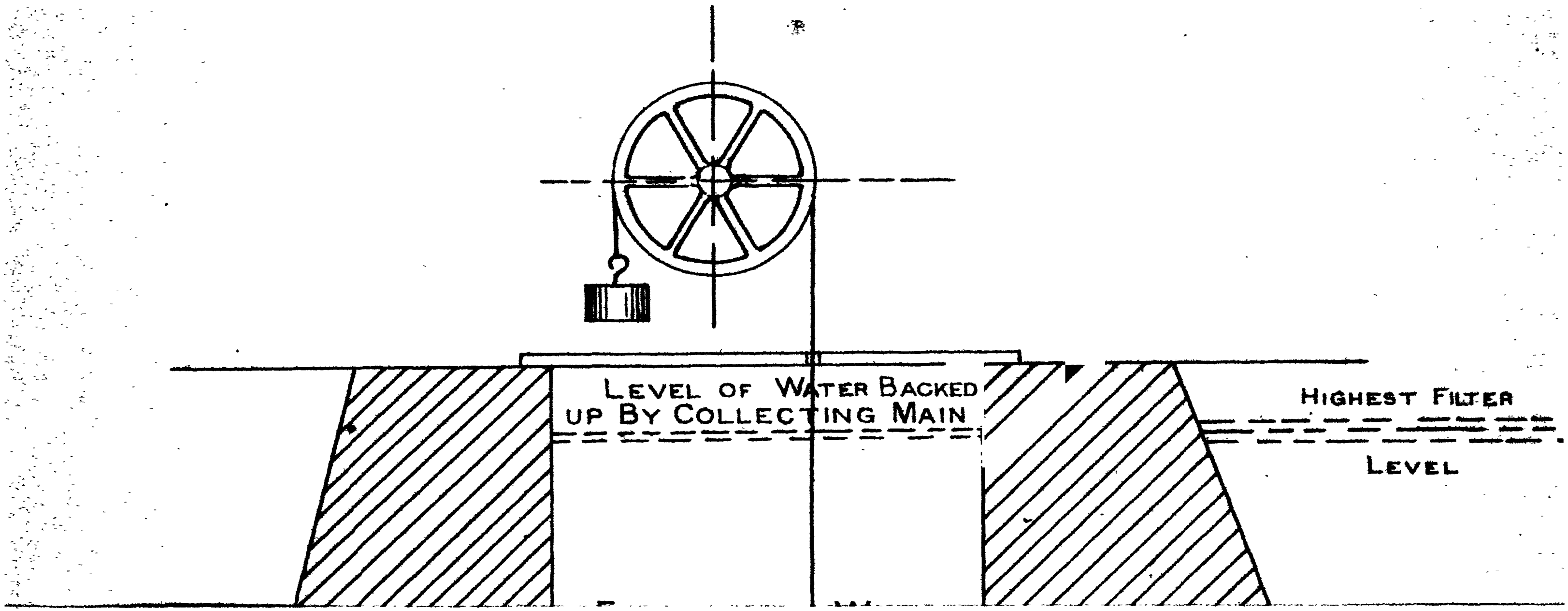
The difference between gauges B and T should of course be $\cdot01392\frac{W}{A}$ foot and constant as long as $\frac{W}{A}$ is unaltered ; the variations above noted are due to accu-

mulations of leaves in front of the grating. In practice no grating is necessary; all leaves, silt, etc., pass easily through the module at all times. In order to read B—T correctly three thin tubes are now being fitted, two to the edge, and one to the centre, of the pressure plate—each connected to a graduated glass tube projecting above the top of the controller. Thus the working head will be read directly, and it will be seen whether there is a diminution of pressure at the edge of the pressure plate, as the writer suspects, or not.



The difficulty of close fitting and friction on the guide stem is largely eliminated by the screwing motion which takes place when the pressure plate is slightly unsymmetrical. But changes in the material and finish of the stem and in the shape of the guide orifices will eliminate this completely.

ALE N FOOT.


LEVEL OF WATER BACKED
UP BY COLLECTING MAIN
HIGHEST FILTER
LEVEL

WATER SUPPLY FOR THE CITY AND CIVIL STATION OF SIALKOTE.

BY

DEWAN AMAR NATH NANDA, B.A.,
Assistant Sanitary Engineer, Punjab.

(SOURCE OF SUPPLY—TUBE WELLS.)

(1) The total supply required for the city, the civil station and the jail is arrived at as follows:—

Population.

Population of the city of Sialkote according to the last census was 47,457 and allowing for a probable future increase of 2,500 during the next 15 years or so based on a rate of increase in Sialkote during the two decades ending in 1911 :—

Total quantity of water required daily.

	gallons.
The total population has been assumed to be 50,000 ; at 10 gallons per head per day the supply for this population will be 50,000 × 10.. ..	500,000
Civil lines including the Police force	10,000
Daily visitors (mostly litigants) 900 @ 5 gallons per head	4,500
Proposed central jail, including the tuberculosis jail, 2,000 @ 15 gallons per head	30,000
Total ..	544,500
or say	5½ lakh gallons.

(2) The supply is to be drawn from tube wells to be sunk 106 ft. below the ground and the source of water being thus deep-seated, there is no fear of contamination from surface percolation. Such being the case, there was no necessity or advantage in going far beyond the confines of the town to obtain a healthy and a reliable supply of water. On the other hand, the nearer the source of supply the cheaper the scheme would be. For this reason the head-works have been located as shown on the attached plans (sheets Nos. 2 & 3). At this place experimental borings were carried out in 1911 and gave very favourable results in respect of both the quality of water obtained and the strata of subsoils met with. A sample of water was analysed by the Chemical Examiner, Lahore, and found to be pure and good.

Site of head-works and the source of supply.

(3) From the geological section of the ground (*vide* sheet No. 1), it is apparent that there is a total depth of 45½ feet of good water bearing stratum composed of strata of varying thickness as the figures given below indicate :—

		Feet.
Below the layer of clay ending at R. L. 771·66 down to R. L. 717·65		54·01

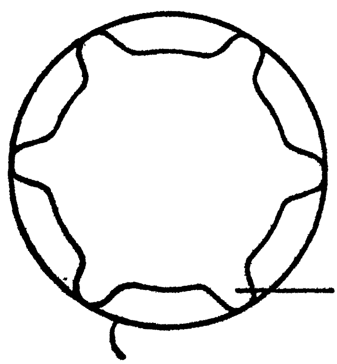
Deduct.—

	Feet	
One stratum of clay and kunkar between R. Ls. 762·40 and 756·90	5·5	
One stratum of fine sand R. L. 735·9 to R. L. 738·9 ..	3·0	
		8·5
Leaving		45·5 feet of good strata.

To obtain the necessary yield it was originally proposed to employ Brownlie's patent convoluted tube wells and for this strainer tubes of 5" dia. and 42 ft. long were selected. This length of tube, according to Mr. Brownlie, is calculated to give a discharge of 11,250 gallons an hour, and assuming the subsoil conditions such as obtain in Sialkote to be favourable for giving the above discharge, the number of wells required to give the needed supply with 10 hours' pumping $= \frac{550,000}{10 \times 11,250} = 4 \cdot 8$ or say 5, and allowing one tube to be always in reserve for cleaning purposes, six tubes were proposed to be put down. Later on another tube—*viz.*, that of Mr. John Ashford's (Superintendent, Canal Workshops, Amritsar) patent make having by actual experiments been proved superior to the Brownlie tube, it was decided by Mr. Aikman, Sanitary Engineer, Punjab, to sink 5" tubes of the latter make having lengths of strainers of 45 ft. Each of these tubes is expected to give a discharge of ½ cusecs or 11,250 gallons an hour, and the specific reasons due to which the 'Ashford' tube has been substituted for the 'Brownlie' one are as stated below :—

Brief description of the Brownlie and the Ashford Tubes.

(*a*) The Brownlie tube wells are made from steel plates bent round so as to have longitudinal convolutions, in my opinion a decidedly weak form of structure, and the straining material, which is wound round this, is of heavy copper wires lying parallel and woven with copper ribbon which prevents slipping or other alteration in the mesh, so that elongated meshes of fine width are produced



through which water can pass into the tube from the surrounding strata of coarse sand. These tubes admit of their being either coupled directly to the pump or

their ends terminating in a masonry sump into which the suction pipe leading to the pumps is also lowered. These patent tubes are manufactured by the Empire Engineering Company, Cawnpore, and can be obtained of 3½", 5", 7" and 9" in diam.

ENLARGED SECTION
OF COPPER WIRE.

*DIRECTION OF WATER

and the boring tubes necessitated for these diameters are 6", 8", 10", and 12" respectively. On the other hand, the 'Ashford' tube is built up of a centring of flat bars and rings round which is wound in parallel lines and 7/1000th of an inch apart heavy copper wire of trapezoidal section, so that the wire strainer round the steel centring forms a wire screen and not a *wire mesh* (as in the case of the Brownlie strainer). The tube is coupled direct to the pump. The sizes manufactured at present at the central canal workshop at Amritsar are 5", 7" and 10" in dia. going into 7", 9" and 12" sinking tubes respectively.

Comparative yields of these two tubes.

(*b*) The comparative yields of these two tubes as given by their patentees are as follows :—

The Brownlie Tube.

Diameter.	Length of strainer.	Discharge cusecs.	Gallons per hour.
3½"	34	¼	5,625
5"	42	½	11,250
5"	54	¾	16,875
7"	54	1	22,500
7"	74	1¼	28,125
9"	95	2	45,000

The Ashford Tube.

Diameter.	Length of strainer.	Discharge cusecs.	Gallons per hour.
5"	35	⅓	7,500
5"	50	½	11,250
5"	100	0·9	20,250
10"	50	1·0	22,500
10"	100	1·8	40,500
10"	120	2·0	45,000

(*c*) (i) For the Brownlie tube the condition laid down is that the maximum working head at which the maximum capacity of the tube is reached is 7 ft., while for the Ashford tube there is no such limit according to the inventor.

Comparative merits of the two tubes.

Pumping head. The head against the engines will be 140 ft., thus :—

	Feet
Static lift from the lowest level in the wells to the F. S. level in the reservoir	118·2
Loss of head due to suction	2·3
Friction	14·8
Extra for bends, etc.	4·7
Total	140·0

The total supply required is 550,000 gallons, and assuming the pumps to work for 10 hours, quantity to be pumped up per minute = 916 gallons.

Therefore P. H. P. $= \frac{916 \times 10 \times 140}{33,000} = 39$.

Pumping plant. The pumping plant will be in duplicate, one of the pumps being capable of pumping the full supply and the other being a stand-by. The pumps will be of the vertical triple expansion surface condensing Worthington type; also there will be two boilers connected with each other and to the pumps so as to be capable of supplying steam to either of the pumps. These boilers will be of the Babcock and Wilcox type provided with superheaters and chain grate mechanical stokers. In the indent sent up for the above machinery high efficiency plant has been demanded so that the consumption of water as steam shall, if possible, not exceed 16—18 lbs. per pump horse-power hour.

Engine house and staff quarters. Drawings of the engine house and machinery foundations will be supplied by the firm who are given the contract for the plant by the India Office.

City service reservoir. The engines will force the water through the rising main to a service reservoir which it is proposed to locate on the top of the old fort (*vide* sheets Nos. 2 and 3). The capacity of this reservoir will be 3 lakh gallons or slightly over half a day's supply, which will be quite ample to balance the maximum demand which usually lasts for 6 hours or so, say 3 hours in the morning and 3 hours in the evening. Originally a mild steel tank (cylindrical in shape) of 40 ft. dia. and 40 ft. high to be placed on a masonry plinth 14 ft. high was proposed. This tank was, however, found objectionable for two reasons :—(1) liability of the water in it to become hot during the summer months, (2) its high figure of cost, *viz.*, Rs. 42,000. A masonry reservoir has, therefore, been proposed to replace the above tank. This reservoir will be built in two compartments each 68 ft. × 36 ft. × 10 ft. (deep), aggregate capacity 3 lakh gallons and will be located as shown on the plans. The mean static head in the former will, however, be 18·36 ft. lower than in the latter and this will necessitate the diameters of the distribution pipes in the distant portions of the distribution being slightly increased. The net saving likely to be effected by the above alteration is Rs. 18,000. The proposed masonry reservoir will be roofed with reinforced concrete slabs 4½″ thick and to keep the water in it cool a layer of 12″ of earth will be laid on top of it.

City distribution. The location of the reservoir on the top of the fort will provide ample head for all purposes. The size of the mains have been calculated from the areas of population served by them. The mean intensity of the population of this town is 170 head per acre, but for the

purpose of the above calculations 200 head per acre have been assumed. In the case of scattered areas sparsely populated 25 per cent. has been added to the actual population. The above thus gives a sufficient allowance for variation in density as well as for future increase. The distribution mains have been calculated allowing for a maximum draw-off of 40 gallons per minute per 1,000 of population. From the larger mains which will be laid in the principal streets and crowded areas 3″ pipes will branch off into various smaller streets forming as it were a grid-iron system over the whole town and feeding almost every corner of it with the least possible length of piping and greatest head. The maximum terminal head in the distant part of the town will be 20 ft.

Stand-posts.

The stand-posts will, as a rule, be placed at street crossings as well as in all such localities where flushing of drains can be facilitated, such as summits of drainage blocks, etc. The total number of stand-posts provided in the city is 145, *i.e.*, one for 345 people; of these, 67 will be combined hydrants and stand-posts and will be erected at the heads of the intramural system of drains, while the remaining 78 will be simple fountain posts.

Waste water meters.

For detecting waste by leakage the town will be divided into two districts. Each of these districts will be isolated from the other by closing certain valves and will thus be brought under the control of a Deacon's waste water meter, two of which will be provided just below the fort; these meters will be placed on a bye-pass.

Progress of work.

Indents for the pipes, valves and the pumping machinery have been sent to England, while work of sinking the tube wells and building the storage reservoir and the staff quarter, is being taken in hand. The whole work is expected to be completed by the end of 1914.

Total cost.

The total estimated cost of the scheme, including P. W. D. Establishment charges, tools and plant, is Rs. 4,59,500, for which the Government have sanctioned a grant-in-aid of one lakh and the balance is payable by the Municipal Committee of Sialkote. The incidence of probable cost per head of population is Rs. 8-8.

Probable cost by sub-heads.

The cost by sub-heads will be as given below :—

	Rs.
I.—Head works—	
(i) No. 6 tube wells including masonry sumps, etc.	15,000
4′ diameter concrete barrel for the suction main.. ..	9,600
Suction pipes and valves	5,200
Wire fencing, iron gate, etc.	1,600
Land	14,700
Total	46,100
(ii) Staff quarters—	
Superintendent's residence with out-houses, etc. ..	5,650
Sudsidiary quarters	2,134
	7,784
Total for (i) and (ii)	53,884

		Rs.
II.—12″ Rising main—with valves, etc.		34,563
III.—City distribution		1,69,730
Civil lines distribution		8,516
IV.—Storage reservoir		20,193
V.—Engine house	10,313	
Pumping Machinery	95,000	
		1,05,313
Total		3,92,199
Add Contingencies on above (exclusive of item of land)		26,424
Public Works Department Establishment charges		40,700
GRAND TOTAL ..		4,59,323

APPENDIX.

Masonry percolation wells as an alternative source of supply.

Rough figure of cost :—

		Rs.
(1) No. 32 wells @ Rs. 3,200 each		1,02,400
(2) Flanged steel suction mains—		
1,920 feet 8″ diameter @ Rs. 4-8-0 R. feet	8,640	
1,680 ,, 10″ ,, @ ,, 6-0-0 ,,	10,080	
200 ,, 12″ ,, @ ,, 7-0-0 ,,	1,400	
Valves, etc.	1,000	
		21,120
(3) Extra length of rising main—		
12″ diameter 2,000 yds.—4,662 cwt. @ Rs. 10 cwt.		46,620
(4) Wire fencing 4,800 feet, iron gate, etc.		2,500
(5) Land for the head-works, 30 acres @ Rs. 200 per acre		6,000
Total		1,79,540

As against Rs. 46,100 which is the probable cost for putting down tube wells.

MILK AND MILK PRODUCTS.

BY

DR. M. SRINIVASA RAO, M.A., M.D., D.P.H.

It is a remarkable fact how free from disease children are, in the first year of life, if we except disorders due to errors in feeding. Breast-fed children are, as a rule, more healthy than those fed on bottle. Mother's milk is nature's provision for the rearing of normal children. In addition to proteids, lactose and salts dissolved in water, milk contains suspended in it an emulsion of fat. Human milk contains these various constituents in such proportions as are suited to the digestive powers of the children, and when for various reasons the mother's milk is not available at all or available in insufficient quantities, the children have to be fed on various substitutes. In the majority of cases, cow's milk is used in preference to anything else. Though the chemical composition of cow's milk is somewhat different from that of human milk, most of the children fed on it seem to thrive. The great difficulty in large towns of which I have personal experience, is that pure unadulterated cow's milk is not available to 90 p. c. of the people. The well-to-do classes can have their own cowsheds and get fresh milk from their own cows. Others can arrange on the payment of a little more money, to get the cows near their own houses and have them milked in their presence. Others again can get fairly good milk from respectable dairies when such exist. But the great majority of middle-class and poor people in the large cities and towns can never hope to get unadulterated milk. Milk, even when it comes from the cow, is always mixed with a larger or smaller quantity of water. Any water is considered to be good enough for adding to the milk. It is not an uncommon thing for the milk-seller to take water from any pond or ditch by the roadside. When there is a public water supply with stand pipes here and there, what is more easy than to open the tap and add the requisite quantity of water to the milk. This is bad enough, but what is worse is that buffalo's milk is generally diluted with 3 to 4 times its quantity of water and passed off as cow's milk. The children fed on such milk usually suffer from digestive disorders which in a large number of cases prove fatal. It is on account of this well-known difficulty of getting good milk, that many of the poorer and even middle-class people resort to the use of various patent foods which are so much lauded in the advertisement sheets of all medical and lay journals. The hard-earned money of the poor goes to swell the coffers of patent food manufacturers.

Except perhaps in the Presidency cities, there is no law imposing any penalties on the adulteration of foods and drugs and even where the laws do exist, they

are not rigorously enforced. According to the "Sale of Milk Regulation" of 1901 in England, milk containing less than 3 p. c. of fats or 8·5 p. c. of solids not fat, is presumed to be adulterated. These standards have been fixed after the analysis of a large number of samples of milk. So far as I know, there were no data in the Mysore Province by which any such standards could be fixed. Therefore, in the latter part of 1910 I began a series of analysis of milk obtained from different breeds of cows commonly found. It is, of course, well known that other factors, such as, the age of the cow, the health of the animal, the stage of the lactation period, the time and method of milking, the food given to the animal and individual peculiarities influence the composition of milk and specially the amount of fat. One hundred and sixty samples of milk from as many animals, were analysed and the results are given in the various statements appended to this paper. Of these, 58 were ordinary cows bred in the Mysore Province. Twenty-seven were of the Baroda breed, 9 of Ajmere, 21 of Delhi, 11 of Saniwal near Lahore. Fifteen animals were of English breed and 4 were half-bred. These animals were all milked either in my presence or before a responsible official sent from the Public Health Institute. Milk from healthy-looking animals alone was taken, and any from those that had apparent symptoms of disease, was rejected. The time of milking was usually that to which the animals had been accustomed. It was not possible to make enquiries into the kind and amount of food given to the cows, and most of them appeared to be in good condition. After the animal had been completely milked, a portion of the milk was taken for analysis.

From the analysis of the 58 samples of milk from cows of Mysore breed (*see* Statement I), it is seen that the average composition is very good, and compares favourably with that of the milk of English cows, *e.g.*, the Jerseys, the Guernseys, and the Devons, which contains on an average, 4·5 to 5·5 per cent. of fat. The figures are:—

Specific gravity	1027	
Total solids	13·11	per cent.
Ash	·69	do.
Fats	4·58	do.
Proteids	3·81	do.
Lactose	4·03	do.
Water	86·89	do.

The milk of one cow contained as much as 8·08 per cent. of fat and another 7·90 per cent. At the other extreme, we have one cow whose milk yielded only 2·60 per cent. of fat, and another 2·70 per cent.

The average, however, is fairly high and Mysore-bred cows apppear to hold their own as rich milkers.

The average of 9 animals of Ajmere breed is somewhat lower than that of the Mysore cows (*see* Statement II). The figures being as follow:—

Specific gravity	1028	
Total solids	12·55	per cent.
Ash	·72	do.
Fats	4·16	do.
Proteids	3·64	do.
Lactose	4·03	do.
Water	87·45	do.

The greatest yield of fat was 5·48 per cent. and the least 2·75 per cent.

27 Baroda cows gave milk having the average composition as follows (*see* Statement III):—

Specific gravity	1028
Total solids	12·44 per cent.
Ash	·70 do
Fats	4·02 do.
Proteids	3·69 do.
Lactose	4·03 do.
Water	87·56 do.

The greatest yield of fat was 6·67 per cent. and the least 1·60 per cent.

21 animals of Delhi breed yielded milk with the following average composition (*see* Statement IV):—

Specific gravity	1025
Total solids	12·95 per cent.
Ash	·69 do.
Fats	3·51 do.
Lactose	4·24 do.
Water	87·05 do.

The variations in the percentage of fat are from 6·07 per cent. to 3·0 per cent.

15 English-bred cows gave a milk which approximated in its composition to that of the Mysore breed (*see* Statement V). The figures are :—

Specific gravity	1027
Total solids	13·44 per cent.
Ash	·75 do.
Fat	4·89 do.
Proteids	3·79 do.
Lactose	4·01 do.
Water	86·56 do.

The richest milk had 9·08 per cent of fat and the poorest 1·49, the variations being more extreme than in the case of other breeds.

There were only 4 half-bred animals and they gave a milk of the average composition as follows (*see* Statement VI):—

Specific gravity	1024
Total solids	13·23 per cent.
Ash	·69 do.
Fats	5·17 do.
Proteids	3·54 do.
Lactose	3·83 do.
Water	86·77 do.

Here also the variations in the quantity of fat are very high ranging from 9·75 per cent. to 1·83 per cent.

Nellore and Ongole cows have a reputation in South India as being very good milkers, but the analysis of the milk of 15 animals shows that they are in no way superior to Mysore cows. The figures are (*see* Statement VII):—

Specific gravity	1027
Total solids	12·79 per cent.
Ash	·72 do.
Fats	4·47 do.
Proteids	3·49 do.
Lactose	4·11 do.
Water	87·21 do.

The milk of only one of them gave as much as 6·07 per cent. of fat, the poorest one giving 2·31 per cent.

11 animals of Saniwal breed gave milk of the following average composition (*see* Statement VIII):—

Specific gravity	**1024**	
Total solids	**13·08**	**per cent.**
Ash	**·69**	**do.**
Fats	**4·97**	**do.**
Proteids	**3·38**	**do.**
Lactose	**4·04**	**do.**
Water	**86·92**	**do.**

The richest milk had 6·98 per cent. of fat, and the poorest 3·74 per cent.

It appears that the amount of fat is subject to great variations ranging from 9·75 per cent. to 1·49 per cent., whereas the amount of the other constituents is far less variable. Thus the maximum and the minimum for lactose is 4·64 and 3·23 per cent., for proteids 4·30 and 2·57 per cent., and for ash ·90 and ·65 per cent., respectively. The variations from the average are the least in lactose and therefore in the detection of adulterations, the percentage of lactose furnishes a better guide than the percentage of fat. The importance of this will be more manifest when the results of analysis of buffalo's milk are considered. A study of the comparative Statement No. IX giving the average composition of milk of different breeds of cows, brings out the salient fact that there is a pretty close agreement in the amounts of the various constituents in the several samples of milk.

The figures obtained by the analysts in England and on the Continent of Europe. differ in some important respects from those now obtained; these are:—

Total solids	12·25	per cent.
Ash	·75	do.
Fats	3·40	do.
Lactose	4·60	do.
Water	87·75	do.

The amount of fat appears to be less by 1 per cent. and of lactose more by ·52 per cent. than in the case of Indian cows. Animals of Delhi breed have more lactose, 4·24 per cent., in their milk than that of any other Indian breed, the average for which is 4·03 per cent.

Milk supplied from Dairy Farms and other places generally consists of the mixed milk of two or more cows. Analysis of 21 such samples of unadulterated milk of Mysore-bred cows, gives results which agree pretty closely with the averages calculated from the results of analysis of the milk of individual cows. (*See* Statement X). The least varying constituent again is lactose.

Seeing that buffalo's milk is sold on a large scale and generally passed off as cow's milk, the milk from 129 buffaloes was analysed in exactly the same way as cow's milk. All the animals were of the Mysore breed and the milk was brought to the Public Health Institute with the same precautions that were observed in the case of cow's milk. Average figures are (*see* Statement No. XI):—

Specific gravity	**1026**	
Total solids	**14·87**	**per cent.**
Ash	**·75**	**do.**
Fat	**6·07**	**do.**
Proteids	**3·92**	**do.**
Lactose	**4·13**	**do.**
Water	**85·13**	**do.**

The examination of a number of samples of mixed milk from a number of buffaloes gave similar results (*see* Statement XII). The results of other analysts either in India or in Europe are not available and hence no comparison is possible.

At any rate, as compared with the milk of Indian cows, we find that the fats, proteids and lactose in buffalo's milk are on an average more by 1·62, ·39 and ·05 per cent., respectively. As a general rule it may be said that buffalo's milk is richer in fat than cow's milk. When we come to individual animals we find that the amount of fat varies from 11·71 to 3·75 per cent. Thus buffalo's milk with a low fat content is hardly distinguishable from ordinary cow's milk. Such samples do not lay themselves open to adulteration on a large scale. It is when the fat content is high, say 7 to 10 per cent., that 2 to 3 times the quantity of water is added to the milk. Such milk would still contain 3 per cent. or more of fat and if the adulteration is tested by the amount of fat only, it would pass muster as coming up to the standard. If too much water is added, the amount of total solids not fat, would no doubt be too low, falling below the standard of 8·5 per cent. But the determination of total solids would take up a lot of time and would require a delicate balance. It is here that a rapid and easy method of estimating the amount of lactose will help the analyst. The percentage of lactose varies remarkably little and taking 4·1 per cent. as the average, not only the fact of adulteration but the extent of it also can be calculated easily. After fixing these standards from the results of analysis of 315 samples of both cow's and buffalo's milk, that the examination of milk generally sold in the bazaar was undertaken. An examination of 51 samples obtained from various parts of Bangalore City, showed that only three were what they were represented to be, *viz.*, 2 cows' and 1 buffalo's undiluted milk, but that 8 were probably cow's milk diluted with varying quantities of water and 40 probably were buffalo's milk adulterated with water ranging from 35 to 65 per cent. In other words, 78 per cent. of the milk sold in the bazaars was buffalo's milk mixed with water. There is no reason to believe that the experience of Bangalore City is in any way exceptional. Other large centres of population are, I fear, in no better position as far as public milk supply is concerned. Some of these specimens of milk show a high fat content going up to as much as 7·54 per cent. Equally good instances of a high fat and low lactose content will be seen from the Statement No. XIII showing the results of analysis of milk sold in the bazaar.

As it is so difficult to get pure cow's milk, some persons bring up their children on goat's milk. The children generally take the milk directly from the goat, the animals being very tame. With a view to ascertain the composition of goat's milk, 8 animals were brought to the Public Health Institute, and they were milked in my presence. The subsequent analyses revealed facts which came upon me as a surprise. The figures given in Jensen's "Milk Hygiene" and Kenwood's "Public Health Laboratory Work" led me to expect some variations in the amounts of various constituents in the milk of Indian goats. The fat content is abnormally high in one, and low in another, the average coming up to 7·41 per cent. The least varying constituent is again lactose which is smaller in amount than either proteids or fats. It is also remarkable that goat's milk has less lactose, 3·49 per cent., than either cow's or buffallo's milk which has an average of 4·1 per cent. (*See* Statement XIV).

A short description of the analytical methods adopted will not be out of place here.

The specific gravity was taken by means of Westphal's balance, but it was found after a few trials that it was unsatisfactory, and was consequently given

up. The use of specific gravity bottle and subsequent weighing in a delicate balance gave reliable and comparable results. The total solids were determined in the usual way by evaporating on a water bath 5 c.c. of milk, then drying in hot air oven and weighing. The residue from the above was incinerated, cooled and weighed for the determination of the ash. The Werner-Schmidt process was used for determining the amount of fat and the figures thus arrived at were checked by Adam's process in a few cases. As the results were practically the same, the use of the latter process was given up as it is one that cannot be used every day in ordinary Public Health Laboratories.

The estimation of lactose was the subject of much difficulty. The processes described in text-books were either too cumbersome or gave varying results. After a large number of trials a process was evolved which appears to be simple and easily carried out in any ordinary Laboratory. To 10 c.c. of milk was added a drop of acetic acid and gently warmed up. When the curd forms it is mixed with 10 c.c. of alum cream and some distilled water and the whole well shaken. All the fat and proteids are separated out. The mixture is then made up to 100 c.c. with distilled water and filtered. The clear filtrate contains all the Lactose found in the original 10 c.c. of milk. It is placed in a graduated burette and dropped into 20 c.c. of Purdy's re-agent previously brought to the boiling point. The dropping of the solution is stopped when the blue colour of Purdy's re-agent just disappears. The Purdy's solution is previously titrated with ·5 per cent. solution of pure lactose and the calculation of the percentage of lactose in the milk from the data thus found is a comparatively easy process. The composition of Purdy's solution is given as it is not in common use in this country or in England. It is made up of the following ingredients :—

Copper Sulphate	4·742	grammes.
Caustic Potash	23·50	do.
Strong Ammonia	450	cubic centimetres.
Glycerine	38	do.
Distilled water up to	1000	do.

The copper sulphate and glycerine are dissolved in 200 c.c. of water with the aid of gentle heat. The caustic potash is dissolved in another 200 c.c. of water. The two solutions are mixed, ammonia added and the volume of the mixture made up to 1 litre exactly. 35 c.c. of this solution are reduced upon boiling by ·02 gramme of glucose. It is always best to standardise the solution against glucose and lactose, as the case may be, each time that the re-agent is freshly prepared. When once the solution is made and standardised, it will keep well for months and this is the re-agent that is in use in the Public Health Institute, Bangalore, for all estimations of glucose or lactose. Fehling's solution may be used, but the great difficulty is to determine the end-point of the re-action when all the copper has been reduced. With Purdy's re-agent the end-point consists in the disappearance of its blue colour. The estimation of lactose in milk or of glucose in the urine by the method sketched above will not take more than 10 minutes. The amount of lactose in very many samples of milk has also been estimated by the use of the Polarimeter. The idea of using this instrument struck me only after about 200 samples of milk had been analysed and as the figures arrived at by the use of the Polarimeter were generally ·01 to ·04 per cent. more

than those obtained by the chemical tests, the latter only are taken to keep up the uniformity of the results.

The amount of proteids was generally obtained by deducting the quantity of fats, lactose and ash from the total solids. In a few cases the actual amount was determined by Kjeldahl's process and was found to be very close to the calculated amount.

Soured milk also known as curds or buttermilk is a very important article of food amongst all classes of Indians. There is no knowing as to when it first came into use. At any rate we may safely assume that it has been a recognised article of dietary for ages. It was only when M. Metchinikoff discovered the use of sour milk by Bulgarians and published it to the Western nations that its value was appreciated. Soured milk is said to be more easily digested than raw or boiled milk. The so-called Bulgarian Bacillus was boomed for all it was worth, but we hear much less of it now-a-days and we may presume that it has found its true level.

Many of the well-to-do people prepare the curds in their own houses. The milk is boiled, allowed to cool somewhat and while still warm, a portion of the curds prepared the previous day is added to it as a starter of fermentation. The vessel is kept in a cupboard at the ordinary room temparature. Many do not allow the fermentation to go on for more than 12 hours, while others who like a more sour mixture let it ferment for 24 or even 48 hours. The curds thus made will practically contain the whole amount of fats, proteids and mineral salts which the original milk possessed, a portion of lactose having become converted into lactic acid. A bacteriological examination of many samples of soured milk showed that in addition to the usual lactic acid producing bacilli, yeasts were present almost always. The soured milk sold in the bazaar is hardly ever made from whole milk. Both buffalo's and cow's milk is deprived of its fat and the skimmed milk is used for the preparation of curds. If the fat is removed by hand churning, from 1 to 2 per cent. of fat generally remains in the milk, but in the skimmed milk from dairy farms where machinery is in use, little or no fat is left in the milk. Though deprived of most or all of the fat, the skimmed milk still remains a valuable food on account of the other constituents present in it. The skimmed milk may also be diluted with water before it is boiled. After cooling, some of the previous day's curds is added to it and fermentation allowed to go on for 2 to 3 days. Such soured milk or buttermilk finds a ready sale in large towns.

It was with the idea of estimating the amount of acid produced that 92 samples of curds were prepared in the Public Health Institute, Bangalore, and subjected to analysis. 50 per cent. or more of lactose appears to be used up in the formation of acid which is expressed in terms of lactic acid in grammes per 100 c.c. of buttermilk. The acidity was determined by the use of decinormal caustic soda solution with phenolphthalein as indicator. The acidity generally attains its maximum on the 2nd or 3rd day and then begins to diminish gradually. If kept for more than 5 or 6 days the acidity greatly diminishes and putrefactive decomposition sets in (*see* Statement XV).

To two samples of milk (82 and 87 in Statement XV) measuring 80 cubic centimeters, a single drop of formalin was added, well shaken and some old curds added to the mixture to start fermentation. It was found that no proper curdling

at all took place even after a stay of 48 hours in the incubator at 37° C. and very little acid was produced even after 8 days. Apparently the drop of formalin either killed off or prevented the growth and multiplication of the lactic acid bacilli. This power of arresting fermentation may be made use of as a test for the presence of formalin in any sample of milk. It may be noted in passing, that the presence of formalin in milk may be detected in the course of the estimation of fats by the Werner-Schmidt process. When a mixture of 10 c.c. of fresh milk with 10 c.c. of strong Hydrochloric acid is heated in the Stokes' tube, it first turns brown and then almost black. But when the milk contains even a trace of formalin, the mixture of milk and acid when heated turns a rose-red or pink colour before becoming dark. With larger quantities of formalin the pink colour passes on almost to deep violet. So far as I know, this fact has not been alluded to in any text-book.

Of the 21 samples of curds purchased in the bazaar, only one showed a large percentage of fat, 4·18, and the majority appeared to have been prepared from skimmed milk sold from dairy farms, the percentage of fat falling so low as ·10 (*see* Statement XVI). The amount of acid appeared to be somewhat less than in the curds prepared in the Laboratory. This may be due to the fact that the acidity had attained its maximum before it was exposed for sale in the bazaar and was diminishing in amount at the time of analysis.

As yeasts were so constantly found to be present in the various samples of curds examined, it appeared reasonable to suppose that they would act upon lactose and convert part of it into ethyl alcohol. To test the accuracy or otherwise of this supposition, 32 samples of buttermilk were examined. 300 cubic centimeters of buttermilk were distilled in the usual way. The resulting distillate had a very sour smell and its acidity was determined after making up its volume to 300 c.c. with distilled water. After neutralisation of the acid with decinormal soda solution, it was redistilled. The distillate was tested for the presence of ethyl alcohol and when the tests were positive, the amount of the distillate was made up to 300 c.c. and its specific gravity and the amounts of alcohol by weight and by volume were determined (*see* Statement XVII). After fermentation for 24 hours, the amount of absolute alcohol by weight is generally 1·05 per cent. It attains its maximum on the 3rd day being 1·87 per cent. and then begins to decrease, the amount on the 9th day being only 0·47 per cent. Considering the quantity of curds generally used by an ordinary person and the small percentage of alcohol present in the curd, there is no danger whatever of any excess of alcohol being ever consumed. There is no fear of any intoxicating effect being produced by taking a pint or even two of buttermilk a day. It may be that during the acid fermentation of milk, a slight alcoholic fermentation goes on side by side and the good effects generally ascribed to the use of soured milk may possibly be due to the gentle stimulating action of small doses of alcohol.

Another milk product that is in universal use in India is ghee. It need hardly be said that ghee is practically butter which has been clarified by being melted. The water is evaporated and any proteids that may remain in the butter are also burnt off. The clarified fat being thus free from water and organic matter, can be preserved for a much longer time than butter. This is an important consideration in a tropical country where butter would soon become rancid and unfit for use. Even the purest ghee when kept for a sufficiently long period will

at last come to have a musty odour too unpleasant to be tolerated. This rancidity is due to the action of microbes and in this process, the insoluble fatty acids tend to increase and the soluble ones to decrease. On account of the large and constant demand among all classes of Indians the price of ghee has gone up beyond all reasonable bounds. There is no article of diet that lends itself so easily as ghee to adulteration and even such adulterated ghee at the present day fetches a higher price than the pure stuff did two decades ago. The manufacturer, and the wholesale and retail dealers are vieing with each other in disguising the real butter fat on its way to the unfortunate consumer. A mere enumeration of all the materials used in making the ghee is enough to make an orthodox Hindu give up the use of ghee altogether. These are mutton fat, beef fat, pig's fat, buffalo's fat, gingelly oil, cocoanut oil, ground-nut oil, castor oil, kusumba oil, plantain pulp, potato pulp, other cheaper starches, jaggery and soft paraffin. Of these, the most commonly used ones are the animal fats on account of their being cheap and easily procurable. Every purchaser asking for ghee knows that the stuff he gets has been adulterated, but he cheerfully pays the price and goes home contented, if not rejoicing.

The problem for the analyst is to have some fixed standards by which he could be guided in pronouncing that a particular sample of ghee has been adulterated and to estimate the approximate quantity of adulteration. In England and other places, margarine is known to be different from butter and any admixture of the animal fats, which compose margarine, with butter, is determined by the use of Reichert-Wollney figure. In other words, the adulteration is detected by estimating the soluble and volatile fatty acids which in butter amount to about 6 to 7 per cent., whereas they are never more than ·75 per cent. in foreign fats. In many Public Analysts' Laboratories in England, the Reichert-Wollney process is now replaced by the simpler and quite as accurate process of Reichert-Meissel. Professor A. E. Leach, analyst of the Massachusetts State Board of Health, in his standard work on "Food Inspection and Analysis," says :—"The Reichert-Meissel number is by far the most important single determination in establishing proof of the character of the sample whether butter or oleo-margarine for evidence in court, and in such cases this determination is indispensable. The result is conclusive, excepting in those rare instances where the admixture of foreign fat is so small as to cause the Reichert-Meissel number to approximate that of pure butter." The following is a short description of this process :—2½ grammes of butter or ghee are weighed into a flask and 10 c.c. of glycerol soda (50 c.c. of 50 per cent. caustic soda solution +250 c.c. of glycerine) added to it. The mixture is heated over a naked flame till the saponification is complete and a clear yellow fluid results. 50 c.c. of boiling distilled water are added to it and after cooling, 10 c.c. of dilute Sulphuric Acid (1 to 9) are mixed with it. The flask is connected with the Reichert-Meissel distilling apparatus and 50 c.c. are distilled, the distillate being made to pass through a dry filter. The flame is so regulated that distillation takes not less than 19 and not more than 21 minutes. The 50 c.c. distillate is then titrated with decinormal soda solution using phenolphthalein as indicator and the number of cubic centimetres added, constitute the Reichert-Meissel figure.

Cow's milk finds such a ready sale that very little of it is ever used for the preparation of butter. By making special arrangements with the proprietor of a dairy, three samples of pure butter from cow's milk were obtained. The Reichert-

Meissel figure of ghee made from these three samples of butter, is seen from Statement XIX to be 13·3 and to be lower than that of ghee made from buffalo's butter.

17 samples of ghee prepared from buffalo's butter were examined (*see* Statement XVIII), the average Reichert-Meissel number being 15·4. The highest figure is seen to be 17·5, and the lowest 14·7.

From an examination of the four animal fats and gingelly oil chiefly used for the adulteration of ghee, 0·6 is taken as the average Reichert-Meissel number for the group of adulterants (*see* Statement XX). Fortunately cocoanut oil is not commonly used for adulterating purposes on account of its strong smell. The difficulties of the analyst would have been greater if cocoanut oil which has a high Reichert-Meissel number had been in common use. Cocoatine which is practically cocoanut oil deprived of its smell is also not used on account of its comparatively high price.

The Polenski value was also determined, but the figures vary so very much that no average useful for the detection of adulteration could be obtained. The Valenta's test was also tried and found to be of some value to the analyst. Many samples of undoubtedly adulterated ghees have fairly high Reichert-Meissel figures and such may have to be passed as pure. But the temperature at which the fats clear up is always higher than in the case of pure ghee. Therefore by the aid of this test, samples Nos. 4, 13, 14, 21, 23, 26, 27, 57, 58 and 59 in Statement XXII were declared to be adulterated.

From the average Reichert-Meissel figures for ghee and adulterants, *viz.*, 15·4 and 0·6 respectively, it is possible to calculate approximately the amount of true butter-fat in any sample sent for analysis. By taking the lowest Reichert-Meissel number for butter-fats and the highest for adulterants, some analysts prefer to give the benefit of doubt to the manufacturer and the tradesman, but this is hardly fair to the consumer. By taking average figures for butter-fat and the adulterants, favour is shown to neither and the ends of justice appear to be better served.

To test if this calculation can be depended upon in practice, the Reichert-Meissel figures for a series of mixtures of pure ghee with the adulterants, in various proportions were determined. The details will be found in Statement XXI. With the exception of those mixed with cocoanut oil, the calculated figures are found to be not very far from the actual quantities taken. On account of the high Reichert-Meissel figures for cocoanut oil, calculations made with the average Reichert-Meissel figure 0·6 for the other adulterants will of course give quite different figures from the quantities actually taken. But if the calculations are made with the Reichert-Meissel figure for cocoanut oil, *i.e.*, 4·1, the figures approximate more or less. This shows the degree of trustworthiness of the Reichert-Meissel figure in detecting the adulteration with foreign fats and also in estimating its amount.

Thus with the combined assistance of Reichert-Meissel figure and Valenta's test, it was possible to declare that of the 62 samples of ghee bought in the bazaar (*see* Statement XXII) 55 were adulterated with foreign fats. Of these, 3 contained no trace of butter-fat, and in others its proportion ranged from 1·3 to 93·2 per cent. Only 7 samples appeared to be fairly pure without any adulteration of foreign fats. In other words, only 11·3 per cent. of the ghee sold in the bazaars may be said to be comparatively pure.

I.—Milk of Country-Bred Cows of Mysore Province.

No.	Description of source of Milk.	Specific gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	REMARKS.
1	Cow supplying milk to Maternity.	1028	12·64	·68	4·08	4·02	3·86	87·36	
2	do.	1030	11·34	·88	2·90	3·78	3·78	88·66	
3	do.	1030	13·08	·66	4·58	3·50	4·34	86·92	
4	do.	1031	12·63	·68	4·33	3·64	4·18	87·37	
5	do.	1028	12·93	·70	4·64	3·53	4·06	87·07	
6	do.	1028	13·11	·77	4·35	3·87	4·12	86·89	
7	Cow in the Fort ...	1024	11·18	·55	3·97	2·90	3·76	88·82	
8	do.	1028	11·77	·70	3·83	2·88	4·36	88·23	
9	do.	1031	12·87	·74	4·31	3·28	4·54	87·13	
10	do.	1029	13·08	·94	4·49	3·57	4·18	86·92	
11	Cow supplying milk to Victoria Hospital.	1028	13·76	·68	5·31	3·42	4·35	86·24	
12	do.	1029	13·36	·83	4·80	3·51	4·22	86·64	
13	do.	1028	15·08	·70	6·17	4·02	4·19	84·92	
14	do.	1029	13·26	·65	4·42	4·18	4·11	86·74	
15	do.	1030	13·35	·65	4·62	3·81	4·27	86·65	
16	do.	1030	13·10	·77	4·21	4·02	4·10	86·90	
17	do.	1027	13·14	·80	4·42	3·81	4·11	86·86	
18	do.	1027	13·61	·75	4·83	3·75	4·28	89·39	
19	do.	1024	16·79	·92	8·08	3·50	4·29	83·21	
20	do.	1025	15·70	·70	7·90	3·44	3·76	84·30	
21	do.	1027	10·85	·60	3·44	2·92	3·89	89·15	
22	do.	1028	12·00	·65	3·22	3·85	4·28	88·00	
23	do.	1026	14·08	·80	5·41	4·12	3·75	85·92	
24	do.	1026	14·03	·80	5·16	4·18	3·89	85·97	
25	do.	1027	12·61	·75	4·07	3·75	4·04	87·39	
26	do.	1029	11·85	·68	3·54	3·81	3·82	88·15	
27	do.	1030	11·45	·68	2·70	3·80	4·27	88·55	
28	do.	1026	12·96	·73	4·30	3·73	4·20	87·04	
29	do.	1027	13·42	·69	4·85	4·06	4·04	86·58	
30	do.	1028	12·31	·67	4·06	3·61	4·03	87·69	
31	do.	1028	12·69	·70	4·41	3·47	4·11	87·31	

I.—Milk of Country-Bred Cows of Mysore Province—(*concld.*)

No.	Description of source of Milk.	Specific gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	REMARKS.
32	Cow supplying milk to Victoria Hospital.	1028	13·60	·83	4·31	4·02	4·44	86·40	
33	do.	1030	10·38	·60	2·79	2·46	4·35	89·62	
34	do.	1028	11·92	·59	3·24	3·98	4·11	88·08	
35	do.	1027	14·47	·70	5·30	4·03	4·04	85·93	
36	do.	1028	12·35	·65	4·41	3·25	4·04	87·65	
37	do.	1029	13·61	·72	4·80	4·18	3·81	86·39	
38	do.	1029	13·86	·73	4·78	4·24	4·11	85·14	
39	do.	1028	12·91	·68	4·39	3·80	4·04	87·09	
40	do.	1029	12·97	·68	3·94	4·24	4·11	87·03	
41	do.	1028	13·39	·70	4·80	3·88	4·01	86·61	
42	do.	1028	14·19	·72	5·27	4·19	4·01	85·81	
43	do. Lunatic Asylum.	1031	13·43	·83	4·30	4·28	4·02	86·57	
44	do. do.	1029	12·64	·68	3·87	3·91	4·18	87·36	
45	do. do.	1031	11·83	·73	2·77	4·07	4·26	88·17	
46	do. Mysore Palace.	1027	13·14	·70	4·84	3·49	4·11	86·86	
47	do. do.	1029	13·45	·72	4·58	4·04	4·11	86·55	
48	do. do.	1028	13·23	·70	4·12	4·22	4·19	86·77	
49	do. do.	1029	13·45	·71	4·83	4·03	3·88	86·55	
50	do.	1027	13·11	·70	4·23	4·07	4·11	86·89	
51	do.	1028	14·17	·75	5·09	4·22	4·11	85·83	
52	do.	1025	17·06	·80	8·01	4·23	4·02	82·94	
53	do. (Amrut Mahal breed)	1029	12·87	·76	4·33	3·60	4·18	87·13	
54	do.	1028	12·59	·74	4·39	3·35	4·11	87·41	
55	do.	1029	15·34	·80	6·35	4·18	4·01	84·66	
56	do.	1026	14·91	·75	6·23	3·91	4·02	85·09	
57	do.	1029	11·02	·73	2·60	3·66	4·03	88·98	
58	do.	1030	14·73	·75	5·97	3·99	4·02	85·27	
	Average	1027	13·21	·69	4·56	3·81	4·03	86·79	

II.—Milk of Cows said to be of Ajmere Breed.

No.	Description of source of Milk.	Specific gravity.	Total Solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	Remarks.
1	Bangalore Palace Cow.	1028	12·82	·82	4·50	3·77	3·83	87·18	
2	do.	1029	13·65	·81	4·14	3·83	4·27	86·35	
3	do.	1029	14·09	·68	5·24	3·99	4·18	85·91	
4	do.	1029	12·68	·68	4·41	3·48	4·11	87·32	
5	do.	1025	13·41	·70	5·12	3·57	4·02	86·59	
6	Mysore do.	1032	10·83	·72	2·75	3·41	3·95	89·17	
7	do.	1028	10·86	·72	2·78	3·35	4·01	89·14	
8	do.	1027	12·10	·76	3·70	3·68	3·96	87·90	
9	do.	1028	13·91	·75	5·48	3·72	3·96	86·09	
	Average	1028	12·55	·72	4·16	8·64	4·03	37·45	

III.—Milk from Cows of Baroda Breed.

No.	Description of source of Milk.	Specific gravity.	Total Solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	Remarks.
1	Cow in Bangalore Palace	1030	13·39	·69	4·13	4·30	4·27	86·61	
2	do.	1033	10 02	·73	1·60	3·60	4·09	89·98	
3	do.	1033	9·72	·69	1 69	3·40	3·94	90 28	
4	do. Mysore do.	1026	13·06	·77	4 81	3·24	4·12	86·94	
5	do.	1025	12·43	·73	4·14	3·44	4·12	87·57	
6	do.	1025	13·67	·72	5·42	3·50	4·03	86·33	
7	do.	1027	13·19	·73	4·75	3·70	4·01	86·81	
8	do.	1028	13 61	·75	4·80	4·04	4·02	86·39	
9	do.	1025	15·05	·78	6·10	4·30	3·97	84·95	
10	do.	1026	12·47	·70	3·91	3·85	4·01	87·53	
11	do.	1026	13·45	·72	5·06	3·65	4·02	86·55	
12	do.	1025	14·54	·74	5·95	3·95	3 90	85·46	
13	do.	1027	12·56	·70	3·71	4·14	4·01	87·44	
14	do.	1028	12·45	·73	4·00	3·62	4 10	87·55	
15	do.	1029	11·12	·72	2 46	3·99	3 95	88·88	
16	do.	1029	10·88	·71	2·58	3·28	4·31	89·12	
17	do.	1031	10·78	·72	2·32	3·74	4·00	89·22	
18	do.	1026	11·61	·70	3·78	3·17	3·96	88·39	
19	do.	1027	12·02	·71	3·18	4·11	4·02	87·98	
20	do.	1026	12·03	·70	4·18	3·14	4·01	87·97	

III.—Milk from Cows of Baroda Breed—(*concld.*)

No.	Description of source of Milk.	Specific gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	REMARKS.
21	Cow in Mysore Palace	1026	13·28	·74	4·89	3·64	4·01	86·72	
22	do.	1025	15·20	·75	6·67	3·87	3·91	84·80	
23	do.	1027	12·42	·68	4·55	3·30	3·89	87·58	
24	do.	1028	12·79	·72	4·26	3·80	4·01	87·21	
25	do.	1031	11·01	·69	3·12	3·77	4·00	88·99	
26	do.	1031	12·43	·75	3·76	3·74	4·18	87·57	
27	do.	1030	10·75	·68	2·68	3·29	4·10	89·25	
	Average ...	1028	12·44	·70	4·02	3·69	4·03	87·56	

IV.—Milk from Cows of Delhi Breed.

No.	Description of source of Milk.	Specific gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	REMARKS.
1	Cow from Military Dairy Farm, Bangalore.	1026	12·18	·69	4·01	3·54	3·94	87·82	
2	do.	1024	14·32	·70	6·07	3·60	3·95	85·68	
3	do.	1026	12·67	·70	3·72	3·61	4·64	87·83	
4	do.	1023	13·75	·70	5·61	3·54	3·96	26·25	
5	do.	1022	13·25	·72	5·11	3·47	3·95	86·75	
6	do.	1024	11·47	·70	3·06	3·84	3·87	88·53	
7	do.	1025	11·53	·69	3·33	3·57	3·94	88·47	
8	do.	1025	13·80	·71	4·97	4·18	3·94	86·20	
9	do.	1028	13·59	·73	5·42	3·51	3·93	86·41	
10	do.	1024	12 62	·72	4·73	2·98	4·19	87·38	
11	do.	1026	11·25	·69	3·00	3·30	4·26	88·75	
12	do.	1024	12·71	·70	4·45	3·53	4·03	87·29	
13	do.	1025	13·31	·72	4·54	3·69	4·36	86·69	
14	do.	1027	11·99	·70	4·01	2·93	4·35	88·01	
15	do.	1025	12·95	·70	4·66	3·48	4·11	87·05	
16	do.	1025	14·14	·71	5·27	3·80	4·36	85·86	
17	do.	1025	14·36	·69	5·80	3·60	4·27	85·64	
18	do.	1025	12·63	·65	4·62	3·09	4·27	87·37	
19	do.	1028	12·47	·68	3·73	3·62	4·34	87·53	
20	do.	1025	12·99	·70	4·64	3·33	4·32	87·01	
21	do.	1024	11·97	·65	4·08	3·05	4·19	88·03	
	Average of 21 cows ...	1025	12·95	·69	4·51	3·51	4·24	87·05	

V.—Cows said to be of English Breed.

No.	Description of source of Milk.	Specific gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	Remarks.
1	Cow supplying milk to Victoria Hospital.	1022	18·10	·82	9·08	4·44	4·06	81·90	
2	do.	1026	15·67	·68	6·68	4·11	4·20	84·33	
3	do.	1025	16·10	·90	6·81	4·42	3 97	83·90	
4	do. Bangalore Palace.	1032	11·82	·74	2·79	4·20	4·09	88·18	
5	do. do.	1033	10·40	·72	1·49	3·98	3·98	89·60	
6	do. do.	1030	13·30	·72	4·35	4·13	4 10	86·70	
7	do. do.	1028	13·91	·78	5·52	3·66	3·95	86·09	
8	do. do.	1027	13·84	·76	4·86	4·04	4 28	86·86	
9	do. do.	1028	13·91	·78	5·68	3·54	4·09	86·09	
10	do. do.	1029	13·22	·70	4·36	3·98	4·18	86·78	
11	do. do.	1029	13·65	·75	4·87	4·08	3 95	86·35	
12	Mysore do.	1026	14·03	·78	6·19	3·79	4·27	85·97	
13	do. Military Dairy Farm, Bangalore.	1024	10·80	·73	4·02	2·68	3·37	89·20	
14	do. do.	1026	10·28	·65	2·78	3·17	3·78	89·62	
15	do. do.	1026	11 40	·75	3·89	2·90	3·86	88·60	
	Average of the 15 cows	1027	13·44	·75	4·89	3·79	4·01	86·64	

VI.—Milk of Cows half-bred (Country Cows covered by English bull).

1	Cow from Military Dairy Farm, Bangalore.	1027	10·03	·68	1·83	3·82	3·70	89·97
2	do.	1017	17·56	·70	9·75	3·38	3·73	82·44
3	do.	1025	12·80	·69	4·60	3·78	3·73	87·20
4	do.	1025	12·34	·68	4·50	3 20	3·96	87·82
	Average of the 4 cows ...	1024	13·23	·69	5·17	3·54	3·83	86·77

VII.—Milk of Cows of Nellore or Ongole Breed (known also as Gokai Breed).

1	Bangalore Palace Cow ...	1025	15·02	·87	5·89	4·18	4·04	84·98
2	do.	1025	14·87	·83	5·83	4·21	4·02	85·13
3	do.	1031	11·49	·68	2·84	4·03	3·94	88·51
4	do.	1030	11·07	·72	2·58	3·53	4·10	88·93
5	Mysore Palace Cow ...	1025	12·63	·68	4·60	3·09	4·26	87·37

VII.—Milk of Cows of Nellore or Ongole Breed (known also as Gokai Breed)—(*concld.*)

No.	Description of source of Milk.	Specific Gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	REMARKS.
6	Mysore Palace Cow	1029	10·90	·65	3·04	2·94	4·27	89·10	
7	do.	1029	9·67	·68	2·31	2·57	4·11	90·33	
8	do.	1026	12·47	·68	4·14	3·37	4·28	87·53	
9	do.	1027	12·41	·70	3·99	3·44	4·28	87·59	
10	do.	1027	12·51	·70	4·46	3·24	4·11	87·49	
11	do.	1026	14·62	·72	6·07	3·87	3·96	85·38	
12	do.	1026	13·86	·78	5·33	3·55	4·20	86·14	
13	do.	1026	13·91	·77	5·81	3·31	4·02	86·09	
14	do.	1026	13·06	·70	4·69	3·65	4·02	86·94	
15	do.	1025	13·80	·72	5·71	3·35	4·12	86·20	
	Average of the 15 cows ...	1027	12·79	·72	4·47	3·49	4·11	87·21	

VIII.—Milk of Cows of Saniwal Breed (Lahore).

No.	Description of source of Milk.	Specific Gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	REMARKS.
1	Cows in Military Dairy Farm, Bangalore	1021	12·48	·73	5·42	3·10	3·63	87·52	
2	do.	1022	12·28	·68	4·52	3·85	3·23	87·72	
3	do.	1026	13·38	·72	5·26	3·79	3·61	86·62	
4	do.	1023	15·58	·75	6·98	3·48	4·37	84·42	
5	do.	1025	12·54	·65	4·60	3·19	4·10	87·46	
6	do.	1023	12·21	·65	4·20	3·10	4·26	87·79	
7	do.	1023	13·31	·70	5·15	3·11	4·35	86·69	
8	do.	1027	11·73	·66	3·74	3·00	4·33	88·27	
9	do.	1025	13·80	·70	5·44	3·57	4·09	86·20	
10	do.	1025	13·68	·73	5·24	3·70	4·01	86·32	
11	do.	1026	12·32	·66	4·07	3·33	4·26	87·68	
	Average of the 11 cows ...	1024	13·08	·69	4·97	3·38	4·04	86·92	

IX.—Comparative statement giving the average composition of Milk of Cows of different breed.

No.	Description of source of Milk.	Specific Gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	REMARKS.
1	Milk of 58 Mysore-bred Cows	1027	13·11	·69	4·58	3·81	4·03	86·89	
2	9 Ajmere do.	1028	12·55	·72	4·16	3·64	4·03	87·45	
3	27 Baroda do.	1028	12·44	·70	4·02	3·69	4·03	87·56	
4	21 Delhi do.	1025	12·95	·69	4·51	3·51	4·24	87·05	
5	15 English do.	1027	13·44	·75	4·89	3·79	4·01	86·56	

IX.—Comparative statement giving the average composition of Milk of Cows of different breed—(*concld.*)

No.	Description of source of Milk.	Specific Gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	REMARKS.
6	4 Half breed Cows	1024	13·23	·69	5·17	3·54	3·83	86·77	
7	15 Nellore do.	1027	12·79	·72	4·47	3·49	4·11	86·21	
8	11 Saniwal do.	1024	13·08	·69	4·97	3·38	4·04	86·92	
	Total Average	1028	12·96	·71	4·60	3·61	4·04	87·04	
	Average of cows of only Indian breeds (omitting the English and Half-bred cow.)	1026	12·82	·70	4·45	3·59	4·08	87·18	
	Average figures given in Jenson's "Milk Hygiene."	...	12·25	·75	3·40	3·50	4·60	87·75	

X.—Mixed Milk of 2 or more cows (Country-Bred).

No.	Description of source of Milk.	Specific Gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	REMARKS.
1	Supplied to Maternity ...	1026	11·40	·60	3·66	3·31	3·83	88·60	
2	do.	1030	12·28	·60	4·11	3·62	3·95	87·72	
3	do.	1029	12·39	.60	4·52	3·32	3·95	87·61	
4	do.	1029	12·53	·77	4·17	3·56	4·03	87·47	
5	do.	1029	13·00	·65	4·20	3·14	4·01	87·00	
6	do. Victoria Hospital.	1027	13·32	·78	4·26	4·19	4·09	86·68	
7	do.	1027	12·85	·77	4·53	3·44	4·11	87·15	
8	do.	1027	13·30	·73	4·55	3·91	4·11	86·70	
9	do.	1027	12·90	·74	4·40	3·63	4·19	87·10	
10	do.	1028	13·37	·73	4·84	3·62	4·18	86·63	
11	do.	1028	13·26	·72	4·33	4·18	4·03	86·74	
12	do.	1026	13·69	·73	4·71	4·21	4·04	86·31	
13	do Palace Bangalore.	1028	13·40	·78	4·47	3·73	3·82	86·60	
14	do.	1029	13·07	·70	4·74	3·45	4·18	86·93	
15	do. Palace Mysore.	1028	12·23	·71	3·74	3·77	4·01	87·77	
16	do.	1030	12·13	·70	3·69	3·56	4·18	87·87	
17	do.	1030	14·07	·77	5·32	3·95	4·03	85·93	
18	do.	1029	14·42	·78	5·73	3·80	4·11	85·58	
19	do.	1030	14·30	·76	5·70	3·74	4·10	85·70	
20	do.	1028	12·69	·70	4·48	3·48	4·03	87·31	
21	do.	1029	14·11	·75	5·60	3·80	3·96	85·89	
	Average	1028	13·17	·72	4·56	3·85	4·04	86·83	

XI.—Milk of Country-Bred Buffaloes.

No.	Description of source of Milk.	Specific gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	REMARKS.
1	Milk of a she-buffalo in Bangalore City.	1033	15·30	·82	5·58	5·58	3·53	84·70	
2	do.	1032	15·84	·87	5·91	4·89	4·17	84·16	
3	do.	1032	16·71	·90	6·05	5·50	4·26	83·29	
4	do.	1029	16·42	·75	7·44	3·96	4·27	83·58	
5	do.	1032	16·18	·77	6·73	4·26	4·42	83·82	
6	do.	1028	17·17	1·31	8·22	4·24	4·28	82·83	
7	do.	1035	17·00	·96	6·57	5·05	4·42	83·00	
8	do.	1028	16·16	·87	6·61	4·31	4·37	83·84	
9	do.	1029	18·05	·97	7·90	5·91	4·27	81·95	
10	do.	1031	14·27	·87	5·20	3·77	4·43	85·73	
11	do.	1025	18·24	·98	9·17	4·26	3·83	82·76	
12	do.	1024	18·76	1·13	9·41	4·41	3·81	81·24	
13	do.	1024	21·29	·97	11·71	4·89	3·72	78·71	
14	do.	1026	15·81	·93	5·92	3·98	4·28	84·99	
15	do.	1028	14·25	·87	6·05	3·05	4·28	85·75	
16	do.	1024	20·45	·95	11·46	4·21	3·83	79·55	
17	do.	1026	15·37	·94	5·78	4·45	4·20	83·63	
18	do.	1025	15·55	·92	7·08	3·65	3·90	84·45	
19	do.	1025	15·86	·98	7·23	3·61	4·04	84·14	
20	do. Mysore Palace.	1030	14·32	·77	5·36	4·09	4·10	85·68	
21	do. Bangalore City.	1031	14·66	·82	4·71	4·45	4·18	85·34	
22	do.	1023	12·42	·53	4·73	3·32	3·84	87·58	
23	do.	1023	12·26	·63	4·94	2·99	3·70	87·74	
24	do.	1031	16·05	·72	6·83	4·50	4·00	83·95	
25	do.	1018	17·28	·68	9·62	3·90	3·08	82·72	
26	do.	1031	13·67	·65	4·15	4·61	4·26	86·33	
27	do.	1029	13·16	·72	5·52	2·74	4·18	86·84	
28	do.	1032	13·32	·68	5·32	3·15	4·17	86·68	
29	do.	1027	13·14	·73	5·15	3·30	3·96	86·86	
30	do.	1026	12·67	·68	5·24	3·00	3·75	87·33	

XI.—Milk of Country-Bred Buffaloes—(*contd.*)

No.	Description of source of Milk.	Specific Gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	REMARKS.
31	Milk of a she-buffalo in Bangalore City.	1031	15·61	·87	6·49	4·07	4·18	84·39	
32	do.	1029	14·41	·72	6·12	3·46	4·11	85·59	
33	do.	1030	16·11	·75	7·53	3·46	4·27	83·89	
34	do.	1030	15·58	·70	6·61	4·09	4·18	84·42	
35	do.	1027	13·80	·70	5·72	3·36	4·02	86·20	
36	do.	1029	14·91	·72	5·77	4·31	4·11	85·09	
37	do.	1029	15·06	·73	6·51	3·87	3·95	84·96	
38	do.	1034	14·84	·77	5·24	4·31	4·52	85 16	
39	do.	1032	14·06	·77	5·09	4·03	4·17	85·94	
40	do.	1030	14·80	·75	5·67	4·36	4·02	85·20	
41	do.	1032	14·42	·81	5·29	4·15	4·17	85·94	
42	do.	1030	14·60	·78	5·38	4·35	4·09	85·40	
43	do.	1033	15·24	·82	5·49	4·68	4·25	84·76	
44	do.	1032	14·06	·78	4·65	4·37	4·26	85·94	
45	do.	1033	13·84	·78	4·51	4·29	4·26	86·16	
46	do.	1032	14·39	·74	5·50	3·66	4·49	85·61	
47	do.	1031	13·68	·73	5·47	3·30	4·18	86·32	
48	do.	1028	13·53	·65	5·44	3·47	3·97	86·47	
49	do.	1031	13·90	·83	5·82	3·73	4·58	86·10	
50	do.	1028	17·96	·68	10·17	3·01	4·10	82·04	
51	do.	1027	14·66	·70	6·49	3·19	4·28	85·34	
52	do.	1029	13·48	·67	5·26	3·37	4·18	86·52	
53	do.	1030	12·48	·63	4·73	3·02	4·10	87·52	
54	do.	1033	12·89	·65	4·12	3·95	4·17	87·11	
55	do.	1029	14·33	·70	6·20	3·40	4·03	85·67	
56	do.	1030	14·80	·71	6·31	3·76	4·02	85·20	
57	do.	1030	13·15	·70	5·43	3·00	4·02	86 85	
58	do.	1029	12·99	·72	4·29	3·95	4·03	87·01	
59	do.	1031	14·08	·68	5·31	3·99	4·10	85·92	
60	do.	1032	11·90	·70	3·58	3·45	4·17	88·10	
61	do.	1029	13·75	·73	5·28	3·47	4·27	86·25	

XI.—Milk of Country-Bred Buffaloes—(*contd.*)

No.	Description of source of Milk.	Specific Gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	REMARKS.
62	Milk of a she-buffalo in Bangalore City.	1030	13·35	·72	5·43	3·02	4·18	86·65	
63	do.	1030	14·07	·75	5·61	3·53	4·18	85·93	
64	do.	1029	14·57	·76	5·67	4·03	4·11	85·43	
65	do.	1031	13·43	·70	5·40	3·16	4·17	86·57	
66	do.	1030	14·68	·78	5·98	3·90	4·02	85·32	
67	do.	1028	13·86	·72	5·51	3·60	4·03	86·14	
68	do.	1030	14·37	·70	5·90	3·50	4·27	85·63	
69	do.	1033	13·35	·71	4·16	3·96	4·52	86·65	
70	do.	1029	14·02	·70	5·44	3·86	4·02	85·98	
71	do.	1028	14·39	·68	5·99	3·61	4·11	85·61	
72	do.	1032	14·50	·72	5·85	3·67	4·26	85·50	
73	do.	1034	14·24	·70	5·51	3·94	4·09	85·76	
74	do.	1033	14·01	·70	5·36	3·86	4·09	85·99	
75	do.	1034	13·20	·75	4·39	3·90	4·16	86·80	
76	do.	1033	13·39	·70	4·74	3·94	4·01	86·61	
77	do.	1027	14·93	·77	5·75	4·38	4·03	85·07	
78	do.	1023	15·05	·72	5·84	4·28	4·21	84·95	
79	dc	1029	14·67	.68	6·51	3·37	4·11	85·33	
80	do	1029	15·09	·71	6·68	3·59	4·11	84·91	
81	do.	1029	14·72	·69	6·61	3·40	4·02	85·28	
82	do.	1027	14·16	·68	5·62	3·91	3·95	85·84	
83	do.	1032	14·83	·62	6·24	3·86	4·11	85·17	
84	do.	1024	18·65	·70	9·91	3·91	4·13	81·35	
85	do.	1024	18·45	·68	9·78	3·94	4·05	81·55	
86	do.	1024	18·55	·69	10·02	3·78	4·06	81·45	
87	do.	1028	13·82	·70	5·72	3·29	4·11	86·18	
88	do,	1027	13·92	·70	6·05	3·13	4·04	86·08	
89	do.	1029	12·58	·60	3·88	4·07	4·03	87·42	
90	do.	1029	13·19	·60	4·66	3·81	4·11	86·81	
91	do.	1028	12·79	·61	4·04	4·10	4·04	87·21	
92	do.	1030	12·72	·65	3·55	4·42	4·10	87·28	

XI.—Milk of Country-Bred Buffaloes—(*contd.*)

No.	Description of source of Milk.	Specific Gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	REMARKS.
93	Milk of a she-buffalo in Bangalore City.	1029	13·44	·62	5·09	3·70	4·03	86·56	
94	do.	1028	12·13	·61	3·75	3·66	4·11	87·87	
95	do.	1029	13·01	·60	4·31	4·07	4·03	86·99	
96	do.	1024	13·33	·62	5·31	3·35	4·05	86·67	
97	do.	1028	13·66	·61	4·72	4·30	4·03	86·34	
98	do.	1029	12·82	·60	4·70	3·49	4 03	87·18	
99	do. Military Dairy Farm.	1024	15·19	·72	6·17	4·03	4·27	84·81	
100	do.	1023	15·01	·71	6·05	4·02	4·28	84·99	
101	do.	1024	16·60	·78	7·55	4·08	4·19	83·40	
102	do.	1025	15·02	·70	5·77	4·28	4·27	84·98	
103	do.	1030	16·68	·75	7·62	4·06	4·25	84·32	
104	do.	1024	14·69	·70	6·42	3·46	4·11	85·31	
105	do.	1026	17·76	·80	8·88	3·90	4·18	82·24	
106	do.	1025	15·89	·72	6·84	4·23	4·10	84·11	
107	do.	1024	17·28	·74	8·75	3·60	4·19	82·72	
108	Milk of a she-buffalo in Military Dairy Farm, Bangalore City.	1023	16·10	·75	7·35	3·98	4 02	83·90	
109	do.	1028	13 83	·70	5·30	4·00	4·10	86·17	
110	do.	1030	12 91	·70	4·09	4·06	4·10	87·05	
111	do.	1029	13·18	·70	4·19	4·12	4·17	86·82	
112	do.	1025	14·69	·70	5·58	4·22	4·19	85·31	
113	do.	1026	15·65	·70	6·76	4·09	4·10	84·35	
114	do.	1024	15·08	·70	5·82	4·21	4·27	84·92	
115	do.	1025	15·81	·73	6·69	4·20	4·19	84·19	
116	do.	1025	14·89	·70	5·81	4·02	4·36	85·11	
117	do.	1023	16·93	·72	7·80	4·21	4·20	83·07	
118	do.	1025	15·52	·71	6·62	4·00	4·19	84·48	
119	do.	1023	15·59	·70	6·63	4·16	4·10	84·41	
120	do.	1026	14·93	·77	6·14	4·00	4·02	85·07	
121	do.	1023	14·39	·75	5·38	4·15	4·11	85·61	
122	do.	1025	15·40	·70	6·45	4·15	4·10	84·60	

XI.—Milk of Country-Bred Buffaloes—(*concld.*)

No.	Description of source of Milk.	Specific gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	REMARKS.
123	Milk of a she-buffalo in Military Dairy Farm, Bangalore City.	1024	16·01	·72	6·81	4·32	4·19	83·96	
124	do.	1022	15·43	·70	6·51	4·02	4·20	84·57	
125	do.	1024	16·07	·70	6·75	4·35	4·27	83·93	
126	do.	1023	14·86	·69	5·97	4·09	4·11	85·14	
127	do.	1024	15·06	·70	5·88	4·11	4·27	84·94	
128	do.	1025	14·68	·72	5·38	4·31	4·27	85·32	
129	do.	1027	15·09	·73	5·83	4·34	4·19	84·91	
	Average	1026	14·87	·75	6·07	3·92	4·13	85·13	

XII.—Mixed milk of 2 or more buffaloes.

No.	Description of source of Milk.	Specific gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	REMARKS.
1	Milk of 16 Buffaloes ...	1028	13·86	·68	5·62	3·68	4·18	86·14	
2	do. 4 do. ...	1029	14·33	·71	6·06	3·38	4·18	85·67	
3	do. 4 do. ...	1031	14·08	·68	5·31	3·99	4·10	85·92	
4	do. 4 do. ...	1020	14·90	·70	6·23	3·79	4·18	85·10	
5	do. 11 do. ...	1027	14·72	·65	6·36	3·66	4·05	85·28	
	Average	1029	14·37	·68	5·92	3·68	4·14	85·63	

XIII.—Milk sold in the Bazaar.

No.	Description of source of Milk.	Specific gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	REMARKS.
1	Said to be mixture of cow's and goat's milk.	1007	5·41	·30	2·73	1·11	1·27	94·59	Probably cow's milk diluted with 69% of water.
2	Said to be buffalo's milk ...	1014	8·87	·56	3·74	2·35	2·22	91·13	Apparently mixed with about 46% of water.
3	Bought in the bazaar ..	1010	6·23	·30	3·28	0·97	1·68	93·77	Buffalo's milk mixed with about 60%
4	do.	1026	10·91	·70	3·06	3·03	4·12	89·09	Apparently of a cow and not watered.
5	do.	1012	6·37	·35	3·16	0·94	1·92	93·63	Buffalo's milk mixed with about 53% o water.
6	do.	1024	11·67	·65	4·35	3·47	3·20	88·33	do. 22% of water.
7	do.	1015	13·25	·55	7·54	2·61	2·55	86·75	do. 38 do.
8	do.	1013	7·45	·48	2·46	2·08	2·43	92·55	do. 40 do.
9	do.	1017	7·12	·35	2·11	2·31	2·33	92·88	do. 43 do.
10	do.	1015	6·50	·26	1·75	2·23	2·26	93·50	do. 45 do.

XIII.—Milk sold in the Bazaar—(*contd.*)

No.	Description of source of Milk.	Specific Gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar.	Water.	REMARKS.
11	Bought in the bazaar ...	1017	8·55	·30	3·54	2·44	2·27	91·45	Buffalo's milk mixed with about 45% of water.
12	do.	1010	6·58	·25	3·14	1·56	1·63	93 42	do. 60 do.
13	do.	1018	6·82	·52	2·23	1 98	2·09	93·18	do. 49 do.
14	do.	1009	6·93	·35	3·39	1·51	1·68	93·07	do. 60 do.
15	do.	1018	8·74	·57	3·32	2·45	2·40	91·26	do. 42 do.
16	do.	1012	5 83	·28	2·11	1·59	1·85	94·17	do. 56 do.
17	do.	1017	6 09	·35	2·08	1·41	2·25	93·91	Probably Cow's milk with about 45% of water.
18	do.	1018	7·98	·25	2·88	2·45	2·40	92·03	do. 42 do.
19	do.	1016	9·64	·40	5·35	1·88	2·01	90·36	Probably buffalo's milk with about 51% water.
20	do.	1023	6·82	·60	1·58	2·39	2·25	93 18	do. Cow's 45 do.
21	do.	1016	11·51	·55	6·10	2·75	2·11	88·49	do. Buffalo's 49 do.
22	do.	1021	10·51	·65	4·93	2·74	2·19	89·49	do. do. 47 do.
23	do.	1012	5·16	·43	1·50	1·23	2·00	94·84	do. Cow's 51 do.
24	do.	1015	6·74	·45	2·52	1·74	2 03	93·26	do. Buffalo's 51 do.
25	do.	1023	7·91	·65	1·27	3·31	2·58	92·09	do. Cow's 37 do.
26	do.	1012	7·75	·30	2·82	2·03	1·90	92·25	do. Buffalo's 54 do.
27	do.	1021	9·64	·65	4·16	2·34	2·59	90·36	do. do. 37 do.
28	do.	1021	10·28	·70	4·01	3·11	2·46	89 72	do. do. 24 do.
29	do.	1026	12·47	·68	4·55	3·20	4·04	87·53	Cow's undiluted.
30	do.	1014	7·59	·45	2·78	2·39	1·97	92·41	Buffalo's with 52 do.
31	do.	1018	9·33	·58	3 61	2·95	2·19	90·67	do. 47 do.
32	do.	1019	9·51	·53	3·49	31·5	2·34	90·49	do. 43 do.
33	do.	1015	8·35	·45	3·62	2·58	1·70	91·65	Buffalo's with 59% water.
34	do.	1018	10·31	·50	5·04	3·04	1·73	89·69	do. 58
35	do.	1011	4·60	·28	1·74	1·00	1·58	95·40	do. 62
36	do.	1020	8·75	·53	3·61	2·75	1·86	91·25	do. 55
37	do.	1022	10·26	·57	4·59	2.84	2·26	89·74	do. 45
38	do.	1014	7·49	·38	2·88	2·54	1·69	92·51	do. 59

XIII.—Milk sold in the Bazaar—(*contd.*)

No.	Description of source of Milk.	Specific gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar	Water.	REMARKS.
39	Bought in the bazaar ...	1008	7·14	·25	3·17	1·70	2·02	92·86	Buffalo's with 51% water.
40	do.	1004	7·42	·21	4·76	1·09	1·36	92·58	do. 67
41	do.	1017	9·28	·35	3·14	2·98	2·81	90·72	do. 32
42	do.	1010	6·93	·25	2·67	1·92	1·99	93 07	do. 52
43	do.	1012	4·44	·18	0·92	1·47	1·87	95·56	Probably skimmed milk diluted with about 55% water.
44	do.	1010	6·48	·25	2·51	1 74	1·98	93·52	Probably Buffalo's milk with about 52% water.
45	do.	1015	5·36	·23	1·12	2·25	1·76	94·64	do. Cow's 57 do.
46	do.	1015	7·68	·33	2 50	2·24	2 61	92·32	do. do. 37 do.
47	do.	1013	7·89	·29	3 49	1·71	2·40	92·11	do. Buffalo's 42 do.
48	do.	1012	8·44	·35	3·87	1·68	2·54	91·56	do. ,, 38 do.
49	do.	1017	9 39	·43	3·78	2·98	2·20	90·61	do. ,, 47 do.
50	do.	1012	7·21	·30	3·79	1·34	1·78	92·79	do. ,, 57 do.
51	do.	1023	15·00	·59	6·41	4·02	3·98	85·00	Probably Buffalo's milk undiluted.

XIV.—Results of Analysis of Goat's Milk.

No.	Description of source of Milk.	Specific gravity.	Total solids.	Ash.	Fats.	Proteids.	Milk Sugar	Water.	REMARKS.
1		1031	17·37	1·05	6·00	6·79	3·53	82·63	
2		1030	18·01	0·95.	6·38	7·26	3·42	81·99	
3		1030	17·91	·92	9·22	4·54	3·23	82·09	
4		1035	18·86	·78	3·58	5·87	3·63	86·14	
5		1029	15·40	·89	6·51	4·23	3·77	84 60	
6		1034	15·95	1·00	6·18	5·35	3·47	84·05	
7		1024	26·66	1·12	15·15	7·00	3·39	73·34	
8		1028	16 92	0·95	6·28	6·21	3·48	83·08	
	Average ...	1030	17·77	0·96	7·41	5·91	3·49	82·23	
	Figures given in Jensen's "Milk Hygiene."		12·70	0·80	3·90	3·50	4·40	87·30	
	do. in Kenwood's "P. H. Laby. Work."		13·96	0·76	4·63	4 35	4·22	86·04	

XV.—Results of Analysis of Butter-milk.

No.	Description of Butter-milk.	After 24 hours of fermentation.				Acidity in terms of grammes of Lactic acid per 100 c.c. of Butter-milk.					Remarks.
		Specific gravity.	Total solids.	Ash.	Milk Sugar.	After 24 hours.	After 48 hours.	After 72 hours.	After 96 hours.	After 120 hours.	
1	Curds made in Laby. from pure milk of a cow, purchased.	1026	12·81	·65	3·96	1·11	1·66	...	1·72	...	
2	do. milk of buffalo.	1022	17·31	1·10	3·20	1·39	2·16	...	2·18	...	
3	do. cow	1017	11·36	·55	3·86	1·51	2·03	...	...	...	
4	do.	1020	10·90	·60	3·10	·86	1·57	1·80	...	...	
5	do.	1020	11·96	·65	2·20	1·12	1·54	...	...	...	
6	do.	1025	12·77	·53	3·49	0·94	...	1·47	...	...	
7	do.	1027	13·82	·70	3·09	0·85	...	1·40	...	...	
8	do.	1025	11·02	·60	2·86	1·48	1·71	...	...	...	
9	do.	1022	10·78	·55	2·62	1·53	1·80	...	...	...	
10	do.	1019	11·03	·50	1·83	2·25	2·25	...	...	...	
11	do.	1014	14·60	·70	1·18	2·16	2·16	...	...	...	
12	do.	1017	14·25	·78	1·91	1·89	1·89	...	...	...	
13	do.	1021	10·43	·73	2·69	1·78	1·89	...	...	...	
14	do.	1017	9·30	·48	1·86	1·57	1·58	...	...	...	
15	do.	1014	11·78	·59	1·97	1·85	1·93	...	...	...	
16	do.	1013	11·94	·74	1·70	1·96	1·98	...	...	...	
17	do.	1020	10·03	·55	2·08	1·87	2·09	...	...	...	
18	do.	1021	8·32	·68	2·26	1·53	1·71	...	1·26	...	
19	do.	1015	10·14	·60	2·49	1·62	1·84	...	1·48	...	
20	do.	1020	7·06	·58	1·44	1·31	1·35	1·57	...	...	
21	do.	1019	11·09	·50	1·62	1·44	1·57	1·71	...	...	
22	do.	1005	17·81	·74	1·08	1·75	1·75	1·59	...	...	
23	do.	1006	9·89	·50	1·68	1·80	1·89	1·85	...	...	
24	do.	1007	13·65	·60	1·70	1·03	1·17	1·17	...	...	
25	do.	1016	9·94	·73	2·18	0·99	1·26	1·35	...	...	
26	do.	1022	9·74	·44	2·26	0·95	1·23	1·39	...	...	
27	do.	1019	13·93	·72	2·28	0·99	1·30	1·35	...	...	
28	do.	1017	10·71	·59	2·14	1·08	1·44	1·53	...	...	
29	do.	1021	10·98	·60	2·21	1·12	1·35	...	1·62	...	

XV.—Results of Analysis of Butter-milk—(*contd.*)

No.	Description of Butter-milk.	After 24 hours of fermentation. Specific Gravity.	Total solids.	Ash.	Milk Sugar.	Acidity in terms of grammes of Lactic Acid per 100 c.c. of Butter-milk. After 24 hours.	After 48 hours.	After 72 hours.	After 96 hours.	After 120 hours.	Remarks.
30	Curds made in Laby. from pure milk of a cow, purchased.	1021	11·21	·62	2·31	1·04	1·44	...	1·75	.	
31	do. milk of cow.	1019	8·04	·50	1·68	1·26	...	1·71	1·80	...	
32	do.	1016	14·21	·72	1·91	1·22	...	1·71	1·76	...	
33	do.	1012	11·65	·62	1·30	1·84	1·89	1·66	...	...	
34	do.	1016	14·23	·75	1·00	1·80	1·84	1·62	...	..	
35	do.	1020	11·71	·68	2·08	1·26	1·66	1·62	...	...	
36	do.	1020	10·68	·53	2·06	1·08	1·44	1·44	...	...	
37	do.	1023	9·76	·62	2·35	1·26	1·57	1·71	...	...	
38	do.	1022	11·35	·65	1·95	1·30	1·62	1·80	...	...	
39	do.	1025	12·12	·78	2·35	1·71	1·84	1·80	...	...	
40	do.	1021	11·31	·73	2·36	1·71	1·80	1·75	...	..	
41	do.	1023	11·82	·83	2·38	1·62	1·71	...	1·57	...	
42	do.	1020	11·56	·73	2·47	1·66	1·80	...	1·62	...	
43	do.	1018	9·92	·64	1·67	1·35	...	1·80	1.75	...	
44	do.	1020	10·93	·68	1·44	1·48	...	1·62	1·57	...	
45	do.	1016	11·56	·72	2·15	2·16	2·12	1·62	...	...	
46	do.	1016	11·41	·70	1·86	2·25	2·43	2·21	...	...	
47	do. buffalo	1013	7·59	·44	0·86	1·12	1·30	1·26	...	...	
48	do. cow	1027	8·61	·89	2·67	1·62	1·75	1·62	...	...	
49	do.	1026	10·90	·63	2·34	1·62	1·94	...	...	1·90	
50	do.	1019	14·81	·91	1·96	1·71	1·80	...	...	0·72	
51	do.	1025	10·84	·83	1·86	1·80	1·71	1·80	...	...	
52	do. buffalo	1015	11·18	·78	1·20	1·44	1·40	1·31	...	...	
53	do.	1019	12·39	·88	1·27	1·66	1·40	1·12	...	...	
54	do.	1026	12·64	·87	2·68	1·48	1·71	1·48	...	...	
55	do.	1022	13·06	·65	1·91	1·57	1·30	1·44	...	...	
56	do.	1023	13·58	·83	1·27	1·62	1·35	1·21	..	...	
57	do. cow	1024	11·08	·87	2·14	1·80	1·80	.....	1·17	...	
58	do. buffalo	1027	11·39	·91	2·22	1·44	1·62	......	1·04	...	

XV.—Result of Analysis of Butter-milk—(*contd.*)

No.	Description of Butter-milk.	After 24 hours of fermentation. Specific gravity.	Total solids.	Ash.	Milk Sugar.	Acidity in terms of grammes of Lactic acid per 100 c.c. of Butter-milk. After 24 hours.	After 48 hours.	After 72 hours.	After 96 hours.	After 120 hours.	Remarks.
59	Curds made in Laby. from pure milk of a cow, purchased.	1022	9·82	·65	2·23	2·07	...	1·62	1·40	...	
60	do.	1022	10·86	·71	2·38	1·17	1·35	1·21	...	...	
61	do.	1020	14·90	·78	2·59	1·21	1·30	1·17	...	...	
62	do.	1025	9·48	·68	2·26	1·62	1·80	1·35	...	...	
63	do.	1018	9·62	·70	1·44	1·80	1·85	1·30	...	...	
64	do.	1025	9·36	·73	2·05	1·89	2·07	1·53	..	...	
65	do.	1023	9·72	·74	1·95	1·67	1·71	1·35	...	...	
66	do.	1029	8·26	·72	2·05	2·07	2·07	1·49	...	...	
67	do.	1028	7·53	·68	2·01	1·75	1·71	1·00	..	...	
68	do.	1028	9·42	·62	2·14	1·89	1·89	..	1·17	...	
69	do.	1028	9·08	·70	2·13	1·80	1·80	...	1·30	...	
70	do.	1017	9·19	·72	1·93	1·98	...	1·53	1·35	...	
71	do.	1025	7·56	·78	2·09	2·16	...	1·98	1·71	...	
72	do.	1016	12·05	·70	2·57	1·84	1·89	1·80	...	...	
73	do.	1015	12·26	·75	2·24	1·71	1·62	0·99	...	...	
74	do.	1020	10·89	·73	2·04	2·02	1·98	1·62	...	...	
75	do.	1019	11·48	·76	1·79	2·07	1·98	1·53	...	..	
76	do.	1020	9·70	·70	2·08	1·98	2·07	1·71	...	...	
77	do.	1019	10·59	·68	1·87	2·16	2·16	1·89	...	...	
78	do.	1025	10·92	·73	1·98	2·02	1·89	1·35	...	...	
79	do.	1023	10·81	·68	2·19	1·93	1·80	1·57	...	...	
80	do.	1011	16·96	·70	1·97	1·89	1·89	1·26	...	..	
81	do.	1019	9·56	·65	2·13	1·89	1·70	...	...	0·58	
82	do.	1014	6·94	·36	1·77	0·24	0·38	0·85	0·90	0·67	On 8th day 0·36 On 10th day ·09 (a drop of Formalin added to milk.)
83	do.	1014	16·86	·69	1·88	2·07	...	...	1·20	0·63	The same ·63 on 6th day.

XV.—Result of Analysis of Butter-milk—(*concld.*)

No.	Description of Butter-milk.	After 24 hours of fermentation. Specific gravity.	Total solids.	Ash.	Milk Sugar.	Acidity in terms of grammes of Lactic acid per 100 c.c. of Butter-milk. After 24 hours.	After 48 hours.	After 72 hours.	After 99 hours.	After 120 hours.	Remarks.
84	Curds made in Laby. from pure milk of a cow, purchased.	1019	10·55	·68	2·17	2·16	...	...	1·93	1·62	On 6th day 1·17. On 7th day ·63.
85	do. buffalo	1020	13·39	·88	1·89	1·48	1·80	2·07	2·16	1·70	7th day 1·53, 8th day ·99, 11th day ·40.
86	do.	1018	14·18	·95	1·82	1·71	2·07	2·16	2·07	1·30	7th day ·81. 11th day ·36 (bad smell from 6th day.)
87	do	...	...	...	..	·36	...	·36	...	...	6th day ·31, 8th ·30, 10th ·36, 12th ·45. (A drop of Formalin had been added to the milk.)
88	do. 2 cows	1020	11·86	·63	1·82	1·98	2·20	2·38	2·38	1·89	
89	do. from milk bought in the bazaar	1004	4·73	·15	0·3	...	1·017	1·053	...	...	
90	do.	1018	9·33	·45	1·50	...	1·83	1·95	...	...	
91	do. of a cow	1018	11·47	·50	2·50	...	1·59	...	1·44	...	7th day 0·28.
92	do.	1022	12·92	·60	2·00	...	1·71	...	2·16	...	7th day 2·16, 12th day 1·26, 15th day 0·54 (bad smell from 12th day.)

XVI.—Butter-milk sold in the bazaar.

No.	Specific gravity.	Total solids.	Ash.	Fats.	Lactose.	Acidity in terms of grammes of Lactic acid per 100 c.c. Butter-milk.											Remarks.
						1st day.	2nd day.	3rd day.	4th day.	5th day.	6th day.	7th day.	8th day.	9th day.	10th day.	11th day.	
1	1026	8·72	·92	1·07	2·49	1·98	2·16	2·16	2·52	2·43	1·41	1·08	0·67	0·36	...	0·31	Bad smell since the 5th day.
2	1022	9·97	·73	4·18	2·65	1·44	1·66	1·66	1·80	1·71	0·81	0·54	...	...	...	...	do. do.
3	1021	5·63	·68	0·24	2·60	0·90	...	1·20	...	1·66	...	...	1·60	...	...	...	Both made from skimmed milk.
4	1025	7·85	·67	0·62	2·85	0·78	...	1·39	..	...	...	...	...	...	...	...	
5	1015	6·69	·69	1·97	1·29	1·80	2·07	2·16	1·89	...	...	0·45	...	...	...	...	Bad smell from 6th day.
6	1021	6·81	·55	1·16	2·49	0·99	1·44	...	...	1·08	...	...	...	...	...	...	do. 5th day.
7	1022	8·36	·50	1·70	2·47	1·08	1·62	...	...	1·26	...	...	...	...	...	...	do. do.
8	1010	5·24	·35	0·52	1·29	1·18	1·71	...	...	...	...	...	...		...	...	Both made from skimmed milk.
9	1014	5·76	·45	0·48	1·28	1·12	1·75	...	...	...	...	...	...	...	...	...	
10	1024	5·51	·52	0·45	2·04	1·29	1·57	...	...	...	...	...	...	...	...	...	do. do.
11	1010	5·04	·56	0·66	0·80	1·39	1·57	...	...	...	...	...	...	...	...	...	do. do.
12	1020	6·56	·49	0·57	1·79	0·81	1·30	...	...	0·76	...	...	...	...	...	...	do. do.
13	1019	5·93	·40	0·46	2·07	1·13	1·53	...	...	1·30	...	...	...	..	...	...	do. do.
14	1022	6·65	·43	0·24	2·33	0·99	1·44	1·64	...	...	...	...	...	...	...	...	do. do.
15	1020	6·37	45	0·22	2·15	1·45	1·57	1·75	...	...	...	...	...	...	...	...	do. do.
16	1017	5·45	·38	0·2	1·86	1·37	1·80	1·39	...	...	...	...	...	0·80	...	...	Stinking on 4th day.
17	1022	7·58	·42	1·08	2·46	1·44	1·99	1·89	...	...	...	...	...	1·35	...	...	
18	1018	6·83	·41	1·69	2·35	0·90	...	1·84	...	...	...	1·44	...	...	·99	...	do. 7th day.
19	1022	6·60	·39	1·27	2·25	1·35	...	1·99	...	...	...	1·49	...	...	·81	...	do. do.
20	1020	5·34	·33	0·30	1·96	1·08	...	1·67	...	...	...	1·44	...		·95	...	Made from skimmed milk.
21	1020	6·17	·37	0·10	2·13	0·81	...	1·57	...	...	...	1·06	...	...	·40	...	

XVII.—Results of Distillation of Butter-milk.

No.	Description of Butter-milk.	Acidity of the distillate in terms of grammes of Lactic acid per 300 c.c.	Specific gravity of the 2nd distillate after neutralising the 1st distillate with N NaOH sol. 10 (at 60°F).	Absolute alcohol by weight.	Absolute alcohol by volume.	REMARKS.
1	Butter-milk prepared in the Laby.	·3024	·9980	1·06 p. c.	1·34 p. c.	
2	do.	·324	·9980	1·06 ,,	1·34 ,,	
3	do. No. 3 in Statement XVI.	·0237	·9980	1·06 ,,	1·34 ,,	
4	The same after keeping 3 days	·0929	·9971	1·62 ,,	2·04 ,,	
5	do. 5 do.	·399	·9980	1·06 ,,	1·34 ,,	
6	do. 7 do.	·8090	·9990	0·53 ,,	0·66 ,,	
7	Butter-milk made in Laby. and 48 hours old.	·143	·9988	0·63 ,,	0·79 ,,	
8	do. 4 days old	·131	·9984	0·84 ,,	1·06 ,,	
9	do. 7 do.	·0877	·9984	0·84 ,,	1·06 ,,	
10	do. 9 do.	·0891	·9991	0·47 ,,	0·60 ,,	
11	Butter-milk No. 8 in statement XVI.	·864	·9989	0·58 ,,	0·73 ,,	
12	do. 9 do.	·761	·9989	0·58 ,,	0·73 ,,	
13	do. 10 do.	·194	·9986	0·74 ,,	0·93 ,,	
14	do. 11 do.	·080	·9987	0·68 ,,	0·80 ,,	
15	do. 12 do.	·0756	·9992	0·42 ,,	0·53 ,,	
16	do. 13 do.	·129	·9990	0·53 ,,	0·66 ,,	
17	do. made from milk in the Laby.	·368	·9989	0·58 ,,	0·73 ,,	
18	do do.	·141	·9985	0·79 ,,	0·99 ,,	
19	do. 14 do.	·117	·9976	1·31 ,,	1·65 ,,	
20	do. 15 do.	·108	·9976	1·31 ,,	1·65 ,,	
21	do. do.	·097	·9979	1·12 ,,	1·42 ,,	
22	do. 17 do.	·139	·9976	1·31 ,,	1·65 ,,	
23	do. 18 do.	·0612	·9975	1·37 ,,	1·73 ,,	
24	do. 19 do.	·0870	·9977	1·25 ,,	1·57 ,,	
25	do. 20 do.	·0846	·9974	1·44 ,,	1·81 ,,	
26	do. 21 do.	·103	·9977	1·25 ,,	1·57 ,,	
27	do. 91 in St. XV	·063	·9973	1·50 ,,	1·88 ,,	
28	do. 91 do. 4 days old.	·018	·9966	1·94 ,,	2·43 ,,	

XVII.—Result of Distillation of butter-milk—(*concld.*)

No.	Description of Butter-milk.	Acidity of the distillate in terms of grammes of Lactic acid per 300 c.c.	Specific gravity of the 2nd distillate after neutralising the 1st distillate with N/10 NaOH sol. (at 60°F).	Absolute alcohol by weight.	Absolute alcohol by volume.	REMARKS.
29	Butter-milk No. 92 in St. XV	·0432	·9972	1·56 p.c.	1·96 p.c.	
30	do. 3 days old.	·288	·9967	1·87 ,,	2·35 ,,	
31	do. 5 do.	·774	·9969	1·75 ,,	2·20 ,,	
32	Butter-milk made in Laby. and kept for 6 days.	·907	·9990	0·53 ,,	0·66 ,,	

XVIII.—Results of analysis of ghee made from Buffalo's butter.

No.	Description.	Reichart-Meissel figure.	Polenski figure.	Solidifying point.	Valenta's test. Temperature at which ghee clears.	Valenta's test. Percentage of absorption of acetic acid.	Specific gravity.	REMARKS.
1	Ghee made from butter bought in Cantonment Market.	17·5	7·2	...	...	...	...	
2	do. Bangalore Dairy.	15·0	4·6	..	...	...	...	
3	do. do.	15·6	5·1	28 deg. C.	38 deg. C.	46·66 p.c.	...	
4	do. do.	16·5	1·4	25 ,,	41 ,,	41·66 ,,	...	
5	do. do.	15·7	3·05	25 ,,	38 ,,	46·66 ,,	...	
6	do. do.	15·3	1·6	31 ,,	42 ,,	40·00 ,,	...	
7	do. do.	14·9	4·8	32 ,,	38 ,,	40·00 ,,	...	
8	do. do.	15·6	3·0	27 ,,	37 ,,	40·00 ,,	...	
9	do. Cantonment Market.	15·4	2·5	31 ,,	37 ,,	37·00 ,,	·8774	
10	do. do.	15·4	3·4	29 ,,	37 ,,	42·00 ,,	·8743	
11	do. City Market	15·3	2·7	33 ,,	45 ,,	42·00 ,,	·8865	
12	do. do.	15·4	2·0	29 ,,	38 ,,	40·00 ,,	·8755	
13	do. bazaar	14·9	1·0	29 ,,	38 ,,	40·00 ,,	·8855	
14	do. do.	15·2	2·0	29 ,,	38 ,,	40·00 ,,	·8796	
15	do. do.	14·7	1·4	27·5 ,,	41 ,,	42·00 ,,	·8765	
16	do. in Dr. M. S. Row's house.	15·5	1·9	28·5 ,,	39 ,,	42·00 ,,	...	
17	do. in Dr. K. R. K. Iyengar's house.	15·0	1·7	27 ,,	37 ,,	41·60 ,,	·8765	
	Average	15·4	2·9	28·8 ,,	39·1 ,,	41·38 ,,	·8794	

XIX.—Results of Analysis of Cow's ghee.

No.		Specific gravity.	Solidifying point.	Reichert-Meissel figure.	Polenski figure.	Valenta's test. Temperature at which the ghee clears.	Valenta's test. Per cent. of absorption of acid.	REMARKS.
1		·8751	29 deg. C.	13·5	2·5	32 deg. C.	40·00	
2		·8865	28 ,,	13 0	7 5	38 ,,	33·30	
3		·8707	31 ,,	13·4	3·2	38 ,,	47·00	

XX.—Analysis of Vegetable and Animal fats used to adulterate ghee.

No.	Description.	Reichert-Meissel figure	Polenski figure.	Valenta's test. Temperature at which fat clears.	Valenta's test. Percentage of absorption of acid.	Specific gravity.	Solidifying point.	REMARKS.
1	Gingelly oil (pure)	0·4	0·5	57 deg. C.	33·3	...	...	
2	do. bought in bazaar	1·3	1·9	54 ,,	39·1	(Average of 4 samples examined)		
3	Cocoanut oil	4·0	9·5	...	...	...	...	
4	do.	4·2	16·6	37·5 deg. C.	66·6 p. c.	·8778	...	
5	Groundnut oil	0 6	1·5	67 ,,	30·0 ,,	·8797	...	
6	Cotton seed oil	2·9	0·8	36 ,,	30·0 ,,	...	...	
7	Cocoatine (an odourless preparation of 3).	5·8	18·0	49 ,,	66·6 ,,	...	...	
8	Soft Paraffin	1·2	0·6	...	...	...	...	
9	Mutton fat (melted and filtered).	0·5	1·9	55 deg. C.	25 p. c.	·8674	...	
10	do. do.	0·5	3·2	55 ,,	25 ,,	...	...	
11	Beef-fat melted and filtered	0·6	2·5	59 ,,	33·3 ,,	...	39·5 deg. C.	
12	Pig's fat do.	0·3	1·0	38 ,,	20 ,,	·8795	38·0 ,,	
13	Buffalo fat do.	1·0	3·4	48 ,,	25 ,,	·8685	41 ,,	
14	Mixture of equal parts of (1, 3, 5, 9, 11, 12 and 13).	0·7	3·4	39 ,,	33·3 ,,	...	...	

XXI.—Reichert-Meissel and Polenski figures of Mixtures of ghee and various adulterants in various proportions.

No.	Description.				Reichert-Meissel figure.	Polenski figure.	Calculated amount of butter fat with R. M. figures 15·4 and ·6 for B. F. and adulterants respectively.	Calculated amount of B. F. with R. M. figures 15·4 and 4·1 for B. F. and cocoanut oil respectively.	REMARKS.
1	Mixture of 50 p. c. of ghee and 50 p. c. of gingelly oil.				8·0	1·4	50 p. c.	...	
2	do.	60	do.	40 do.	9·6	1·1	60·8 ,,	...	
3	do.	40	do.	60 do.	6·7	1·0	40·5 ,,	...	
4	do.	70	do.	30 do.	11·0	2·2	70·2 ,,	...	
5	do.	30	do.	70 do.	4·6	4·8	27·0 ,,	...	
6	do.	80	do.	20 do.	13·0	2·6	83·7 ,,	...	
7	do.	20	do.	80 do.	3·8	5·3	21·6 ,,	...	
8	do.	90	do.	10 do.	13·8	5·0	89·2 ,,	...	
9	do.	10	do.	90 do.	2·0	1·8	9·4 ,,	...	
10	Mixture of 50 p. c. of ghee and 50 p. c. of cocoanut oil.				10·3	6·1	...	54·7 p. c.	
11	do.	75	do.	25 do.	13·0	3·5	...	78·7 ,,	
12	do.	25	do.	75 do.	6·9	9·0	...	24·7 ,,	
13	do.	60	do.	40 do.	9·8	5·5	...	50·4 ,,	
14	do.	40	do.	60 do.	8·0	5·5	...	34·9 ,,	
15	Mixture of 50 p. c. of ghee and 50 p. c. of groundnut oil.				7·9	2·8	49·3 p. c.	...	
16	do.	60	do.	40 do.	8 8	5·4	55·4 ,,	...	
17	do.	40	do.	60 do.	5·9	1·5	35·7 ,,	...	
18	Mixture of 60 p. c. of ghee and 40 p. c. of mutton fat.				9·5	1·9	60·1 ,,	...	
19	do.	40	do.	60 do.	6·6	3·2	40·5 ,,	...	
20	do.	75	do.	25 do.	11·2	2·6	71·6 ,,	...	
21	do.	25	do	75 do.	4·0	2·9	22·9 ,,	...	
22	Mixture of 50 p. c. of ghee and 50 p. c. of beef fat.				7·9	1·9	49·3 ,,	..	
23	do.	60	do.	40 do.	9·2	1·9	58·1 ,,	...	
24	do.	40	do.	60 do.	6·4	2·3	39·2 ,,	...	
25	Mixture of 60 p. c. of ghee and 40 p. c. of pig's fat.				9·3	1·6	58·8 ,,	..	
26	do.	40	do.	60 do.	6·1	3·3	37·2 ,,	...	
27	Mixture of 40 p. c. of ghee and 60 p. c. of buffalo's fat.				6·2	2·7	37·8 ,,	...	

XXII.—Results of Analysis of samples of ghee purchased in the bazaars.

No.	Deciription of Butter-milk.	Reichert-Meissel figure.	Polenski figure.	Valenta's test. Temperature at which fat clears.	Valenta's test. Per cent. of absorption of acid.	Calculated amount of B. F. with R. M. figures 15·4 and ·6 for B. F. and adulterants, respectively.	Remarks.
1	Bazaar ghee	2·6	12·0	59 deg. C.	33·3 p. c.	13·5 p. c.	
2	do.	0·3	2·8	57 ,,	33·3 ,,	No butter fat at all.	
3	do.	14·5	2·3	40 ,,	33·3 ,,	Probably pure ghee.	
4	do.	14·0	2·3	49 ,,	36·6 ,,	90·5 p. c.	
5	do.	0 6	1·7	55 ,,	25·0 ,,	No butter fat at all.	
6	do.	1·3	1·0	59 ,,	26·6 ,,	4·7 p. c.	
7	do.	2·1	1·5	62 ,,	40 ,,	10·1 ,,	
8	do.	14·9	4·2	41 ,,	42 ,,	Probably pure ghee.	
9	do.	15·0	2·7	41 ,,	33·3 ,,	do.	
10	do.	0·8	2·0	58 ,,	33·3 ,,	1·3 p. c.	
11	do.	13·5	2·3	42 ,,	40 ,,	87·1 ,,	
12	do.	1 0	2·6	59 ,,	33·3 ,,	2·7 ,,	
13	do.	13·0	3·0	49 ,,	40 ,,	83·7 ,,	
14	do.	13·5	2·0	44 ,,	42 ,,	87·1 ,,	
15	do.	0·9	1·0	48 ,,	33·3 ,,	2 0 ,,	
16	do.	16·7	3·2	39 ,,	33·3 ,,	Probably pure ghee.	
17	do.	13·6	5·2	42 ,,	47 ,,	87·8 p. c.	
18	do.	0·9	2·7	45 ,,	46·6 ,,	2·0 ,,	
19	do.	0·6	2·5	46 ,,	40 ,,	No butter fat at all.	
20	do.	14·0	1·9	42 ,,	50 ,,	90·5 p. c.	
21	do.	13·5	2·4	44 ,,	41 ,,	87·1 ,,	
22	do.	13·5	2 0	42 ,,	50 ,,	87·1 ,,	
23	do.	13·8	2·0	47 ,,	50 ,,	89·2 ,,	
24	do.	0·7	3·5	44 ,,	40 ,,	0·7 ,,	
25	do.	14·3	1·7	42 ,,	43·3 ,,	Probably pure ghee.	
26	do.	13·4	3·4	47 ,,	40 ,,	86·5 p. c.	
27	do.	14·2	3·5	46 ,,	36·6 ,,	91·9 ,,	
28	do.	14·5	3·6	42 ,,	36·6 ,,	Probably pure ghee.	
29	do.	2·0	4·9	52 ,,	43·3 ,,	9·4 p. c.	
30	do.	1·1	1·3	52 ,,	40 ,,	3·4 ,,	
31	do.	15·0	2·5	39 ,,	50 ,,	Probably good ghee.	

XXII.—Results of Analysis of samples of ghee purchased in the bazaars—(*contd.*)

No.	Description of Butter-milk.	Reichert-Meissel figure.	Polenski figure.	Valenta's test. Temperature at which fat clears.	Valenta's test. Per cent. of absorption of acid.	Calculated amount of B. F. with R. M. figures 15·4 and ·6 for B. F. and adulterants respectively.	REMARKS.
32	Bazaar ghee.	1·2	1·6	55 p. c.	40 p. c.	4·0 p. c.	
33	do.	1·1	1·1	51 ,,	40 ,,	3·4 ,,	
34	do.	1·1	1·4	59 ,,	46·6 ,,	3·4 ,,	
35	do.	4·0	1·7	59 deg. C	40 ,,	24·3 ,,	
36	do.	2·1	4·3	51 ,,	40 ,,	10·1 p. c.	
37	do.	14·7	2·0	41 ,,	50 ,,	Probably good ghee.	
38	do.	1·9	2·6	48 ,,	41·6 ,,	8·8 p. c.	
39	do.	1·7	3·5	61 ,,	42 ,,	7·4 ,,	
40	do.	1·2	1·9	45 ,,	50 ,,	4·0 ,,	
41	do.	1·0	1·1	46 ,,	33·3 ,,	2·7 ,,	
42	do.	8·0	2·8	52 ,,	46·6 ,,	50·0 ,,	
43	do.	1·8	6·3	49 ,,	35·3 ,,	8·1 ,,	
44	do.	1·3	2·8	69 ,,	40 ,,	4·7 ,,	
45	do.	13·0	7·3	52 ,,	33·3 ,,	83·7 ,,	
46	do.	1·3	5·8	55 ,,	40 ,,	4·7 ,,	
47	do.	1·5	1·7	42 ,,	25 ,,	6·1 ,,	
48	do.	3·9	3·6	48 ,,	26·6 ,,	22·3 ,,	
49	do.	10·8	3·4	40 ,,	40 ,,	68·9 ,,	
50	do.	8·0	7·0	46 ,,	36·6 ,,	50·0 ,,	
51	do.	8·6	6·8	45 ,,	40 ,,	54·0 ,,	
52	do.	1·5	2·2	70 ,,	40 ,,	6·1 ,,	
53	do.	3·7	1·0	54 ,,	33·3 ,,	20·9 ,,	
54	do.	13·2	1·5	49 ,,	26·6 ,,	85·1 ,,	
55	do.	11·7	2·0	58 ,,	33·3 ,,	75·0 ,,	
56	do.	10·8	2·2	52 ,,	33 3 ,,	68·9 ,,	
57	do.	14·1	1·9	53 ,,	50 ,,	91·2 ,,	
58	do.	14·3	3·4	54 ,,	33·3 ,,	93·2 ,,	
59	do.	13·2	2·0	56 ,,	33.3 ,,	85·1 ,,	
60	do.	2·0	1·0	65 ,,	25 ,,	9 4 ,,	
61	do.	11·2	1·7	53 ,,	33·3 ,,	71·6 ,,	
62	do.	1·5	1·9	60 ,,	33·3 ,,	6·1 ,,	

OBSERVATIONS ON THE BACTERIOLOGICAL AND CHEMICAL EXAMINATION OF THE MILK SUPPLY OF BOMBAY.

BY

DR. LEMUEL LUCAS JOSHI, M.D., B.SC., D.T.M.,
Municipal Analyst, Bombay.

WITH AN INTRODUCTORY NOTE

BY

DR. JOHN A. TURNER, M.D., D.P.H.,
Executive Health Officer, Bombay Municipality.

THE problem of supplying pure and clean milk to large cities has been found to be a most difficult and perplexing one and has not been completely solved even in Europe and America. Rosenau of the U. S. A. says :—" There is probably no single problem in the whole realm of modern sanitation and hygiene that is so complex, so involved, so intricate, and so harassing." If this is so in a most progressive country like the United States, it is much more true in India, where the milk problem is in a most deplorable condition. This may be ascribed to various factors, such as climatic influences, peculiar customs and habits of the people, illiteracy and ignorance of the farmers and the ordinary milk vendors, lack of proper legislative control, etc.

There are several aspects of the milk problem in India which require a thorough investigation on the part of the scientist, the practical sanitarian, the economist, the sociologist, and the legislator. The present investigation has been undertaken with a view of finding out the extent of adulteration and pollution of milk in Bombay and of establishing local milk standards which, with some modifications, may be applied to other cities in India.

SOURCES OF THE MILK-SUPPLY OF BOMBAY.

(1) In the City and Island of Bombay :—

(*a*) Individual purveyor or gowlee.

(*b*) Milk shops, etc.

(*c*) Dairies.

(2) From the Suburbs.—Most of which are situated on the Island of Salsette.

Milk is supplied in the city in three ways :—

(*a*) by the *individual milk vendor or gowlee* who usually hawks about from house to house distributing milk to his customers. The milk is generally contained in brass vessels of varying sizes which are either carried on the head or allowed to hang from a pole slung across the shoulders. There are at least three kinds of *lotas* used—each *lota* containing milk of different quality and price. Adulteration is very common except in the case of high priced milk sold by a few honest gowlees ;

(*b*) by *milk shops*, halwais' (sweet-meat sellers) shops, etc. These shops are numerous in the 'native' part of the town. Here also adulteration is almost the rule ;

(*c*) by the *dairies*—it is estimated that there are about thirty-six dairies in Bombay. The milk supplied by the majority of these dairies is by no means of a superior quality. Many of the dairies sell milk in special bottles or in closed milk cans which are locked and sealed. In spite of all these precautions it is found that only a few dairies can be depended upon to supply genuine and clean milk.

Number of milch-cattle and stables.—During 1912-1913, 83 stables for 13,968 milch-cattle were licensed in Bombay. Besides the licensed cattle, a number of milch-cattle belong to private owners, the Bombay Panjrapole, etc. The number of these animals is roughly estimated to be at least 3,000, so that the total number of milch-cattle in the *City and Island of Bombay* may be taken at about 17,000.

A very important source of the milk-supply of Bombay is the Island of Salsette—no record is available with regard to the amount of milk imported in Bombay city from the suburbs. It is usually conveyed in railway trains in a most primitive and insanitary manner. There are no " milk trains " nor are there any special " milk cars." The milkmen crowd into the ordinary third class compartments along with other passengers, shelving their open milk cans under the dirty seats. The cans are covered only along the edges with concentric rings of straw, which is supposed to prevent the spilling of the milk. The filthy condition of an ordinary third class car, the dirt and dust flying into the open milk vessels, and the habits of most of the passengers occupying a third class compartment can be more easily imagined than described. The milk has already been drawn under the most insanitary conditions and after a slow journey of two or three hours under the above conditions arrives at its destination in Bombay and thence distributed to the public. The high temperature adds further to the most favourable conditions for bacterial growth. The condition of the milch-cattle stables *including those belonging to most of the dairies* is indescribably and hopelessly filthy. The vessels in which milk is drawn are by no means scrupulously clean. It is a rare thing to see either the udders of the animals or the hands of the milkman being thoroughly washed before milking. Besides, the water added for adulteration is usually unfit for drinking purposes—cow-dung being not an uncommon constituent of adulterated milk.

The accompanying paper relates only to a part of the investigation carried on by Dr. Lemuel L. Joshi. From his researches on the bacteriology and chemistry of the Bombay milk-supply, two facts at least are quite apparent :—(1) *That there is great deal of adulteration of milk in Bombay ;* and (2) *that the contamination of Bombay milk with fæcal and other objectionable organisms is very high.* What is true for Bombay is probably true for other large cities of India. The paper clearly shows the importance of bacteriological examination. The standards proposed by

Dr. Joshi are reasonable and are based upon many years of work carried on in the Municipal laboratory, Bombay. I agree with him that the chemical standard should be legalised as early as possible. The bacterial standard however needs further research and it may be suggested that similar investigations should be undertaken in other parts of India.

Granted then, that the adulteration and pollution of milk is carried on a large scale in India, what are some of the practical remedies for the eradication of the evil ? As far back as 1907, I drew the attention of the Municipal executive to the desirability of better legislation regarding the control of milk. I repeatedly pointed out that the provisions of Sections 415 and 416 of the Municipal Act do not give sufficient powers to the Municipality to exercise proper control over the milk-supply of the city. In 1911, I made definite suggestions for amending and revising the milk regulations. The points involved were the following :—

(1) The Registration and Licensing of places for the sale of milk.
(2) The granting of licenses to hawkers of milk.
(3) The authorisation of Officers of the Municipality empowered by the Commissioner and not being below the rank of Food Inspectors, to arrest, and to take to the nearest Police Office, persons bringing in articles referred to in Section 415.
(4) The fining of sellers or importers of milk adulterated with water or milk unfit for human food.

The amendments, etc., proposed with regard to these points were forwarded to Government, by the Corporation, on 4th September 1911. As a result of this, the following amendments, etc., have been made :—

Bombay Government Gazette, 2nd October 1913.

BOMBAY ACT, No. VI OF 1913.

Para. 7.—After Section 412 of the said Act the following new Section 412-A shall be inserted, namely :—

License required for dealing in milk.

" 412-A. No person shall without or otherwise than in conformity with terms of a license granted by the Commissioner in this behalf :—

(*a*) carry on within the city the trade or business of a dealer in or importer or seller or hawker of milk ;
(*b*) use any place in the city for the sale of milk."

As regards *the terms under which licenses could be granted* in connection with the two clauses of this Section, the following rules have been drawn up :—

Under clause (*a*) of Section 412-A.

1. All dealers, importers, sellers, or hawkers of milk in public places must have their names and addresses marked upon the vehicles or cans.

2. All milk exposed for sale must be declared as pure buffalo or cow milk or skimmed milk.

3. No dealer, importer, seller, or hawker of milk shall cause or suffer any cow or buffalo belonging to him or under his care or control to be milked for the purpose of obtaining milk for sale—

(*a*) unless, at the time of milking, the udder and teats of such cow or buffalo are thoroughly clean;

(b) unless the hands of the person milking such are thoroughly clean and free from all infection and contamination; and

(c) unless the milk-receiving vessel is thoroughly clean and rinsed with clean boiling water.

4. Every dealer, importer, seller or hawker of milk shall take all reasonable and proper precautions in connection with the collection, storage and distribution of the milk, and otherwise, to prevent the exposure of the milk to any infection or contamination.

5. He shall not keep milk for sale, or cause or suffer any such milk to be placed in any vessel, receptacle or utensil which is not thoroughly clean.

6. He shall cause every vessel, receptacle, or utensil used by him for containing milk for sale to be thoroughly cleansed with steam or clean boiling water after it shall have been used, and to be maintained in a constant state of cleanliness.

7. He shall not convey any milk for sale or distribution in open vessels, but the latter shall be provided with proper close fitting covers under lock and key and a tap at the lower end through which the milk shall be retailed to the customers. If the milk is distributed in cans they shall also be provided with properly fixed covers.

8. He shall not at any time mix with other milk, or sell or use for human food, the milk of any cow or buffalo which may be suffering from tuberculosis, rinderpest, foot and mouth disease, or disease of the udder, which may be certified by a Veterinary Surgeon to be tubercular.

Our existing bye-laws 4 and 5 framed under clause (j) and which provide against any person suffering from dangerous or infectious disease selling or distributing milk and which prohibit a milk seller from knowingly coming in contact with diseased persons, may be added to these regulations.

Under Clause (b) of Section 412-A.

1. He shall not keep any milk intended for sale in any room or place where it would be liable to become infected or contaminated by impure air, or by any offensive, noxious, or deleterious gas or substance, or by any noxious or injurious emanation, exhalation, or effluvium.

2. He shall not keep any milk intended for sale in any room used as a kitchen or as a living room or in any room where any other trade is carried on, or in any room or building, or part of a building communicating directly by door, window, or otherwise with any room used as a sleeping room, or in which there may be any person suffering from any infectious or contagious disease, or which may have been used by any person suffering from any such disease and may not have been properly disinfected.

3. He shall not keep any milk intended for sale in any room or building or part of a building in which there may be any direct inlet to any drain, or which opens on to a gully, or in which a privy or water-closet opens directly.

4. He shall at all times protect the milk which is intended for sale from dust and flies by providing suitable covers to the milk vessels.

5. He shall not retail the milk to his customers by dipping his hands into the vessels, but the latter shall be provided with taps at the lower end through which the milk shall be drawn.

6. He shall cause the floor and drain of every such room or place, and every counter, shelf, or bench on which milk vessels are kept, to be washed and thoroughly cleansed daily.

7. He shall cause every vessel used in his milk shop to be rinsed with boiling water and thoroughly cleansed, before and after use.

8. He shall cause the floor of every such milk shop to be paved throughout with suitable impervious material approved by the commissioner, and the paving shall be so sloped as to ensure effectual drainage having a gradient of not less than 1 in 30.

9. He shall cause every part of the internal surface of the walls and ceiling of every such milk shop to be thoroughly lime-washed twice at least every year, or oftener if so required by the commissioner.

OBSERVATIONS ON THE BACTERIOLOGICAL AND CHEMICAL EXAMINATION OF THE MILK SUPPLY OF BOMBAY.

BY

DR. LEMUEL LUCAS JOSHI.

BEFORE proceeding to relate and discuss the results of the bacteriological and chemical examination of the Bombay milk supply, it would be well to state the main factors which influence the chemical and bacterial content of milk. These factors will have to be borne in mind while discussing the results of the present investigation. It would be impossible to go into all the details as the space at my disposal is very limited. Only a brief summary is therefore given below:—

EXISTING CONDITIONS AFFECTING THE CHEMICAL COMPOSITION AND BACTERIAL CONTENT OF MILK OBTAINED IN BOMBAY.

(1) Breed of cattle.
(2) Effect of feeding.
(3) Time of calving.
(4) Age of the animal, etc.
(5) Influence of temperature and humidity.
(6) Seasonal variations.
(7) Housing of animals—particularly the condition of the milch-cattle stables.
(8) Diseases of the milch-cattle.
(9) Habits and customs of the *gowlees* and milk vendors—the method of milking, etc.
(10) Communicable diseases of the milkmen, *e.g.*, tuberculosis.
(11) Several miscellaneous factors contributing towards the contamination of the milk supply during transit from producer to consumer, *e.g.*, condition of the milk vessels, mode of transportation, etc.

BACTERIOLOGICAL EXAMINATION.

The samples of milk were collected in special bottles provided for the purpose and were stoppered and sealed in the usual way. They were examined as soon as possible after collection. The following routine was followed in the examination of the samples:—

(1) *Preliminary dilution of the samples with sterile water.*—These were made in a series of test-tubes as follows:—1 : 10, 1 : 100, 1 : 1,000, 1: 10,000, 1 : 100,000, and one in a million. These dilutions were used for (2) and (3).

(2) *Microbes per c.c.*—Agar plates were used for this purpose and a count was made after incubating for 48 hours at 37° C.

(3) *Lactose Fermenters.*—MacConkey's Bile-Salt Medium (with Lactose) was used in Durham's fermentation tubes and the results noted with regard to acid and gas formation. The dilutions used were from 1 : 10 to 1 : 1,000,000.

(4) *B. Enteritides Sporogenes.*—15 c.c. of the sample were used. The milk was heated for 15 minutes at 80° C., rapidly cooled, incubated anærobically, and was examined for the characteristic changes from four to five days.

(5) *B. Coli-like Organisms.*—These were isolated on Neutral Red Agar and examined for acid and gas formation (MacConkey's Bile-Salt Media) and for Indol Test.

(6) *Cholera.*—Cultures were made on Peptone water and examined for cholera in the usual way.

(7) *Typhoid.*—Drigalski and Conradi's medium and Neutral Red Agar were used.

(8) *Examination of the Centrifugalised Sediment.*—50 c.c. of the milk were centrifugalised in the electric centrifuge for about ten minutes. Smears were made from the deposit, stained with Carbol-fuchsin (1 : 10) and examined microscopically for Leucocytes, Streptococci, Staphylococci, and other micro-organisms, etc., that may be present.

(9) *Tuberculosis.*—The results of examination for tubercle bacilli are described separately on page 156.

The samples of milk examined bacteriologically may be divided into three classes :—(1) Those collected from healthy animals under the strictest precautions and examined *immediately* after collection. (2) Those collected by the Chief Veterinary Inspector and his staff with ordinary precautions and sent to the Laboratory, the time elapsing between the collection and examination varying from *three to four hours.* (3) Those bought at random in the different wards of the city from dairies, milk shops, cattle-stables, railway stations, *gowlees* and other milk vendors, by the staff of the Health Department. These samples fairly represent the quality of milk as is usually sold to the public in Bombay. As the "morning milk" is taken between 2 and 4 A.M., and sold a few hours later in the Bazar, *six to nine hours* pass before it arrives for examination at the Municipal Laboratory.

I. *Samples collected at the Municipal Laboratory under the strictest precautions.*—Several cows and buffaloes belonging to a dairy were brought over to the Municipal Laboratory after being examined by a Veterinary Surgeon and certified to be entirely free from disease. The animals were thoroughly scrubbed and washed. Just before milking, the udders and neighbouring parts were washed first with an antiseptic solution and finally with sterile water. The milking was done by the manager of the dairy himself, his hands being rendered surgically clean in the usual way. Most of the milk was drawn in sterile glass beakers while a few drops were drawn directly into slant agar tubes. After making the necessary dilutions, the samples were immediately subjected to the routine examination for microbes per c.c., Lactose fermenters, etc., with the following results :—

1. *Microbes per c.c.*—The average of several samples was found to be 386 *microbes per c.c.* This was probably due to the too frequent manipulations involved in diluting the milk and preparing the plates, etc. The slant agar tubes in which milk was directly drawn were found to be sterile. This would indicate

TABLE A.

Date.	No.	Microbes per c.c. on Agar at 37° C. for 48 hours.	B. Coli-like organisms.	B. Typhosus.	B. Ent. sporogenes.	Cholera vibrio.	Lactose Fermenters.	Microscopic Examination of the Deposit. Streptococci.	Staphylococci.	Other microbes.	Leucocytes.
17-6-13	1	4,100,000	—	—	—	—	— in one c.c.	—	—	—	+
	2	1,700,000	—	—	—	—	" "	—	—	—	"
	3	450,000	—	—	—	—	" "	—	—	—	"
	4	3,650,000	—	—	—	—	" "	—	—	—	"
26-6-13	5	3.500,000	—	—	—	—	" in ·001 c.c.	—	—	—	"
	6	5,250,000	—	—	—	—	" in "	—	+	—	"
	7	27,550,000	—	—	—	—	" in "	—	+	—	"
	8	25,650,000	—	—	—	—	" in "	—	+	—	"
5-9-13	9	23,350,000	+	—	—	—	" in ·000001 c.c.	—	+	+	"
	10	11,350,000	+	—	—	—	" in ·00001 c.c.	—	—	+	"
	11	35,450,000	+	—	—	—	" in "	—	+	+	"
	12	8,550,000	—	—	—	—	" in ·000001 c.c.	—	+	+	"
	13	36,850,000	+	—	—	—	" in "	—	+	—	"
	14	46,150,000	+	—	—	—	" in "	—	—	+	"
25-9-13	15	5,700,000	+	—	—	—	" in ·00001 c.c.	—	+	+	"
	16	6,050 000	+	—	—	—	" in "	—	+	—	"
	17	5,050 000	—	—	—	—	" in ·0001 c.c.	—	—	+	"
	18	5,050,000	—	—	—	—	" in "	—	—	—	"
	19	6,400,000	—	—	—	—	" in "	—	—	—	"
	20	5,400,000	—	—	—	—	" in "	—		—	"

+ = detected. — = not detected.

that milk drawn with strictest precautions from healthy and clean animals is practically sterile.

2. *Lactose Fermenters* were absent in 1 c.c. and less of milk.

3. Examination for B. Coli communis, B. enteritides sporogenes, streptococci, cholera vibrio, B. tuberculosis and B. typhosus was negative.

II. *Samples collected by the Chief Veterinary Inspector and his staff with ordinary precautions.*—Twenty samples were examined in all—eight in June and twelve in September 1913. The results are given in Table A.

It will be seen from this table that B. enteritides sporogenes, streptococci, cholera vibrio and B. typhosus were not detected in any of the samples. B. coli-like organisms were detected only in seven samples. This leaves only microbes per c.c. and lactose fermenting organisms. Taking first the *microbes per c.c.*, it will be seen that the highest count was found to be 46,150,000 mic. per c.c., while the lowest count was 450,000 mic. per c.c. The average number expressed in millions was as follows:—

TABLE B.

Date.	Number of samples examined.	Average number of microbes per c.c.
June	8	8,981,250
September	12	16,195,833

TABLE C.

MICROBES PER C.C. IN 20 SAMPLES EXPRESSED IN MILLIONS.

Less than 1 million.	More than 1 but less than 3.	Above 3 but less than 5.	Above 5 but less than 10.	More than 10 but less than 20.	Above 20 but under 50.
1	1	3	8	1	6

The majority of samples showed a count of more than five millions of microbes per c.c.

The above figures are only approximate, for as Savage says: "There are no nutrient media and no known conditions of growth which will allow *all* the bacteria in milk to develop."

Lactose fermenters.—Out of the twenty samples examined, only four or 20 per cent. did not show any lactose fermenters in 1 c.c. and less of milk. The following results were obtained :—

TABLE D.

LACTOSE FERMENTERS IN 20 SAMPLES OF MILK (Class II).

No. of samples.	1·0 c.c.	0·1 c·c.	0·01 c.c.	0·001 c.c.	0·0001 c.c.	0·00001 c.c.	0·000001 c.c.
4	—	—	—	—	—	—	—
4	+	+	+	+	—	—	—
4	+	+	+	+	+	—	—
4	+	+	+	+	+	+	—
4	+	+	+	+	+	+	+
TOTAL 20							

+ = Present.
— = Absent.

These results compare favourably with those obtained in the third series of samples (*see* Table G).

III. *Samples bought at random from a variety of sources*, e.g., *dairies, milk shops, cattle-stables, railway stations, individual milk-vendors or gowlees, etc.* (103). One hundred and three such samples were examined in the same manner as Series I & II. Only a brief summary of the results is given below :—

1. *Microbes per c.c.*—The highest count was 118,400,000 mic. per c.c., and the lowest was 250,000 mic. per c.c. during a period of six months. The highest average figures were reached during May as will be seen from Table E.

TABLE E.

MICROBES PER C.C.—AVERAGE OF 103 MILK SAMPLES (Class III).

Date.	No. of samples.	Average of total count of microbes per c.c. on agar, at 37° C. for 48 hrs.
April, 1913	12	46,363,000
May, „	30	63,481,700
June, „	2	34,125,000
July, „	31	35,801,612
August, „	10	29,750,000
October, „	18	38,027,777
TOTAL ..	103	

TABLE F.

MICROBES PER C.C. IN 103 SAMPLES OF MILK EXPRESSED IN MILLIONS (Class III).

More than 1 but less than 5 millions.	More than 5 but less than 10 millions.	More than 10 but less than 20 millions.	More than 20 but less than 30 millions.	More than 30 but less than 50 millions.	More than 50 millions.
2	9	10	27	15	40

The majority of samples (nearly 80 per cent.) showed a count of more than 20 millions; while about 39 per cent. showed more than fifty millions of microbes per c.c.

2. *Lactose fermenters.*—The results are tabulated below:—

TABLE G.

LACTOSE FERMENTERS IN 103 SAMPLES OF MILK (Class III).

No. of samples.	Dilutions of milk used.						
	1 c.c.	0·1 c.c.	0·01 c.c.	0·001 c.c.	0·0001 c.c.	0·00001 c.c.	0·000001 c.c.
2	+	+	+	+	—	—	—
1	+	+	+	+	+	—	—
19	+	+	+	+	+	+	—
81	+	+	+	+	+	+	+
TOTAL 103							

+ = Present.
— = Absent.

All the samples showed the presence of lactose fermenting organisms in 1 c.c. and less of milk. Out of the 103 samples, 81 or 78·6% showed lactose fermenters in the weakest dilution used, *viz.*, in 0·000001 c.c. of milk. Lactose fermenters were found to be absent in 0·0001 c.c. and *less* of milk in two samples only. These results are extremely bad when compared to those in Series II (*see* Table D).

3. *B. enteritides sporogenes.*—13 samples out of 103 or 12·6% gave positive tests with the production of the characteristic changes in the milk. Animal experiments were tried in a few cases but with negative results.*

4. *B. coli-like organisms* were detected in 96 samples, giving 93·2 per cent. as compared with 35% in Series II.

5. *Streptococci.*—The centrifugalised stained deposit examined microscopically showed the presence of streptococci in 13 samples out of 103 or in 12·6 per cent.

6. *Examination for B. typhosus and cholera vibrio was negative* in all cases.

* From the Municipal Laboratory Records, it appears that in 1906 out of 166 samples of milk examined for B. ent. sporogenes, the milk test was positive in 95 or 57·23%.

A few remarks may be now made regarding some of the above results. *Microbes per c.c.*—As has been already said, *all* the colonies counted at any one time do not by any means give a *true* count of all the bacteria present in milk, for there are so many varieties of microbes found in milk that it is impossible for them *all* to grow on the *same* medium. It cannot be denied, however, that the count has a *relative* value when made under precisely identical conditions. It may be argued that all the bacteria found in milk are not harmful. It must be remembered however that milk containing an excessive number of microbes cannot be said to be a suitable food, particularly for infants. Besides 93·2% of the samples examined showed the presence of coli-like organisms or fæcal bacilli. Unfortunately milk is not a transparent liquid or else the enormous growth of microbes would have been quite visible to the naked eye. To get some idea of the bacterial counts found in Bombay, the figures may be compared to those of sewage in London and Boston, and of milk in London, New York, Boston and Bombay.

TABLE H.

Sewage in	Average for	Microbes per c.c.	Name of the Investigator or Authority.
(1) London ..	1894-1901	2,000,000 to 11,000,000	Rosenau
(2) Boston ..	1894-1901	2,800,000	
Milk in—			
(1) London ..	December to February ..	3,000,000 to 5,000,000	Eyre.
	June to September ..	20,000,000 to 30,000,000	
(2) New York ..	In winter	1,000,000	
	„ summer	5,000,000	Park.
(3) Boston ..	1904	2,300,000	Bergey.
(4) Bombay ..	April to October 1913 (103 samples)	41,258,000	Joshi.

It must be borne in mind that too much stress should not be laid on these statistics, as different investigators may have employed different methods and the results may not be strictly comparable. At any rate it is quite evident that Bombay enjoys the dubious honour of standing *first* in the above list !

There are at least *three main factors which influence the multiplication of bacteria in milk :* (1) time, (2) temperature, and (3) conditions of collection and transportation of milk.

(1) *Time.*—By "time" is meant the interval between the withdrawal of milk from the cow or buffalo and its examination at the laboratory. A glance at the figures given on pages 150—152, will show the following :—

	"Average Time."	Average number of Mic. per c.c.
Class I	Immediate Exam.	386.
Class II	3 to 4 hours	12,588,000
Class III	6 to 9 hours	41,258,000

In these experiments, the temperature was practically constant, but the conditions of collection, etc., were different and this must be borne in mind when

comparing the results. The following figures from Freudenreich are very instructive :—

Shortly	after milking, the sample contained			9,000	mic. per c.c.	
1 hour	,,	,,	,,	31,750	,,	,,
2 hours	,,		,,	36,250	,,	,,
4 ,,	,,	,,	,,	40,000	,,	,,
7 ,,	,,		,,	60,000	,,	,,
9 ,,	,,		,,	120,000	,,	,,
25 ,,	,,		,,	5,000,000		

It may be concluded then, that under identical conditions of collection, transportation, etc., and with a constant (optimum) temperature, the longer a milk sample is kept, the greater the number of bacteria in it.

(2) *Temperature.*—This is a very important factor here in India. It has been found that the majority of bacteria met with in milk grow best at about 25° C. to 35° C. or (77° F. to 95° F.). At lower temperature (15° C. and below) they multiply very little. At higher temperature, the different bacteria have their different *thermal death points*. The atmospheric temperature in Bombay corresponds very closely to the most favourable temperature for bacterial growth in milk, namely, 25° C. to 35° C. or 77° F. to 95° F., and accounts partially for the high counts obtained. It will be seen from Table " E " that the highest number of microbes per c.c. (46 to 63 millions) was found during April and May which are the hottest months in Western India. In July and August on account of the monsoon it is comparatively cooler in Bombay and correspondingly the figures show a lower count (29 to 35 millions) than in April and May.

(3) *Conditions of collection, transportation, etc.*—These have been already mentioned in the Introductory Note of the paper. The cleanliness of the methods employed in milking, etc., has a direct bearing on the bacterial content of milk. It affects not only the total *number* of bacteria but also the *kind* of bacteria in milk. The dirtier the milk the greater is the number of microbes in it. This has been clearly proven by the results already tabulated under *three different classes* of samples collected under widely different conditions.

The enumeration of microbes per c.c. in milk serves as an index to its (1) age, (2) temperature at which it was held, and (3) the cleanliness of the methods employed in its collection, etc. A favourable combination of all these three factors will result in an excessive multiplication of the bacteria present.

As regards the presence of *lactose fermenting organisms* in Bombay milk a comparison may be made between the figures in Table ' D ' and those in Table ' G.' In the former case only 20% samples showed lactose fermenters in 0·000001 c.c. and more of milk, while in the latter case, the percentage of samples showing lactose fermenters in the same dilution was 78·6, or nearly four times as much. In the former B. coli-like organisms were found in 35% of the samples, while in the latter in 93·2%. The presence of organisms of the B. coli group in such large numbers indicates pollution with cow-dung, etc. This is not at all astonishing, when one remembers the filthy condition of the stables where milking is carried on. Out of the samples of milk collected with the strictest sanitary precautions, not one showed any "fæcal bacilli." This taken together with the results tabulated in Tables 'D' and 'G' would indicate that the presence and number of lactose fermenting organisms of the B. coli type in milk depend mostly on the amount of cleanliness observed in milking, transporting, etc. The figures for milk of Class III (Table 'G') show

an appalling amount of manurial and other undesirable pollution of Bombay milk as is ordinarily found in the local market, dairies, milk shops, etc.

The value of bacteriological examination of milk in India cannot be denied in the light of the above results. Chemical examination is no doubt important, as it gives us information as to whether a sample of milk is genuine or not, that is whether it is "watered" or otherwise. If clean and pure water be added, it would not be directly injurious to health. If however a sample of milk shows a very high count of bacteria, most of which are of fæcal origin, or the presence of a pathogenic microbe, then its bearing on health is quite evident. Again, a sample of milk may be quite genuine from a chemical point of view, but very objectionable from a bacteriological standpoint. The following two samples (A & B) may be cited to illustrate this point:—

TABLE I.

Date.	Samples.	Chemical Examination.				Bacteriological Examination.	
		Spec. gra. 60° F.	Total @ Solids %	Fat %	Solids not fat %	Mic. per c.c.	Lactose fermenters present in
23-7-13	"A"	1,030	17·14	6·5	11·14	47,100,000	·000001 c.c. & more.
6-8-13	"B"	1,026	15·44	6·4	9·04	52,850,000	·000001 c.c. & more.
						(B. coli-like organisms present in all.)	

Both the samples are *genuine* from a chemical point of view. Bacterial examination shows, however, a very high count, presence of lactose fermenters in 0·000001 c.c. and more, and the presence of B. coli-like organisms! Surely, such samples cannot be considered harmless specially for the tender gastro-intestinal mucous membrane of an infant.

Space will not permit me to discuss the other results. The practical importance of bacteriological examination of milk is excellently summed up by Rosenau:—"The activities of our health officers were at first directed almost exclusively to the prevention of sophistication of milk detected by chemical methods, to the neglect of the valuable information obtained from bacterial examinations. The addition of water to milk and the extraction of cream are fraudulent practices, but, as a rule, have only a secondary bearing upon the public health. The bacteriological examination of milk gives us a clue to the cleanliness of the methods employed, the temperature, and the age of the milk. The Health Officer who has the advantage of bacteriological assistance knows that the milk of dairies containing excessive numbers of bacteria is dirty, old, or warm. With a bacteriological count as a guide it is comparatively easy to determine the cause of the trouble and to institute proper means to correct it. The enumeration of bacteria in milk is, therefore, one of the readiest and cheapest methods at the disposal of health officers to determine the general sanitary quality of the market milk supply." Dr. Eastwood's report to the Local Government Board (1909) says:—"Routine bacteriological examinations of samples, for the guidance of the milk inspection service, are valuable, and should be adopted. They afford the most reliable, the cheapest, and often the quickest means of discovering when milk has been improperly handled."

The only question remaining to be considered now is, ***are tubercle bacilli conveyed by milk in India?***

There are hardly any statistics available in India with regard to the prevalence of tuberculosis in milch cattle. No systematic investigation seems to have been made as yet, but judging from the reports of the Chief Veterinary Inspector of Bombay and others, it appears that Indian cattle rarely suffer from tuberculosis. If this is so, it may be partly ascribed to the fact that in India, cattle are allowed to graze out in the open all the year round (excepting in large cities), and live an out-door life more than in England or in America.

Tubercle bacilli in milk.—The following figures will show the frequency with which tubercle bacilli have been found in milk in English and American cities :—

Cities.	No. of samples examined.	Percentage containing Tubercle bacilli.	* Investigators or Authorities
London (1908)	..	11·6	William G. Saage.
Manchester (1908)	..	8·28	William G. Saage.
New York (1910)	107	16·0	Hess.
Chicago (1910)	144	10·5	Tonney.
Washington (1906)	233	6·7	Anderson.

* Quoted by Rosenau.

A systematic examination of Bombay milk for B. tuberculosis was made by the writer during three years (1910, 1911 & 1912). The total number of samples examined were 614. 47 samples or 7·6 per cent. showed the presence of *acid fast bacilli* but *in not a single sample tubercle bacilli could be demonstrated by animal experiments.* These results have been confirmed independently by those at the Bombay Bacteriological Laboratory, Parel, where 100 samples of cow's milk were recently examined for tubercle bacilli but *in no instance did the guinea-pigs develop turberculosis.* Further investigation in other cities of India is necessary before drawing final conclusions, but so far as our present knowledge goes, it may be concluded that *in India, tubercle bacilli are rarely, if at all, conveyed by milk.*

Chemical Examination of Milk, and the question of Standards for India.

It is well-known that the chemical composition of milk in India differs in many respects from that of Europe and America. This is largely due to the fact that in India one has to deal with buffaloes' milk as well as cows'. The former shows a higher percentage of proteids and fats than the latter. Buffaloes' milk was first examined by F. Strohner in 1888. In 1890, Peppel and Richmond investigated the milk of the " Gamoose" in Egypt. Indian buffaloes' milk was examined by Leather in 1907, and by Meggit and Mann in 1907-1908. At the Municipal Laboratory, Bombay, the chemical examination of milk dates back to 1903. A special investigation was carried on here during 1905—1910. The best and most recent work of reference published in India on this subject is the paper in two parts by Mr. A. A. Meggit and Dr. H. H. Mann in the "Memoirs of the Department of Agriculture in India," Vol. II, Nos. 1 & 4.

Average composition of Indian buffaloes' milk.

The following figures are for Poona and Bombay.

TABLE J.

Complete analysis of Indian buffaloes' milk.

	Sp. gr. at 15·5°C.	Solids not fat. %	Water. %	Fat. %	Proteids. %	Milk-Sugar. %	Mineral matter %
1. *Poona* (Kirkee) .. *(Leather).	1032·1	9·69	82·22	8·09	4·34	4·56	0·76
2. Bombay (50 Samples) .. (Municipal Analyst).	1031·5	9·3	82·5	8·2	4·0	4·9	0·8

* Quoted by Meggit and Mann.

For a routine examination of milk, the only constituents that need to be estimated are, *Specific Gravity* (usually at 15·5° C. or 60° F). *Fat*, and *Total Solids*. "*Solids not fat*" being obtained by deducting the figures for *Fat* from *Total Solid*. Great variations have been found, depending on various factors, such as age and breed of the animal, the kind of feed, time of calving, season, etc. It appears, for iustance, that the amount of milk given by the "Delhi" and "Jafferabadi" buffaloes is usually more than the yield of the "Surati" buffaloes. The milk of the latter breed, however, is found to be much richer in fat than the others. It is a matter of common experience that *food* rich in proteids and fat will yield milk of a superior quality. This is why cotton seeds, *chuni* (husk of Cajanus Indicus) and oil cakes form a part of the daily ration of the milch-cattle in Bombay. The kind of food given is just as important as the breed of the animal. Take for instance, a fine "Sindhi" cow with full udders, etc., and feed it on food poor in fat and nitrogenous matter—the milk will remain poor in quality in spite of the good breed.

271 Samples of "genuine" buffaloes' milk examined at the Bombay Municipal Laboratory, gave the following figures :—

TABLE K.

Average Composition of "Genuine" Buffaloes' Milk in Bombay.

Month.	No. of samples examined.	Specific gravity at 60°F.	Total Solids. %	Fat. %	Solids not fat. %
January	31	1029·41	17·76	8·21	9·55
February	30	1029·79	17·35	7·7	9·65
March	9	1028·83	16·94	7·11	9·83
April	20	1029·06	17·37	7·57	9·80
May	26	1029·36	16·96	8·15	8·81
June	22	1028·63	17·45	7·81	9·64
July	33	1028·58	17·50	7·64	9·86
August	30	1027·41	17·73	8·06	9·67
September	13	1028·18	16·75	7·33	9·42
October	17	1028·07	17·04	7·41	9·63
November	24	1029·30	16·57	7·26	9·31
December	16	1029·77	16·94	7·22	9·72
Total ..	271	1028·86	17·11	7·62	9·57

The average figures, then for "mixed" buffaloes' milk in Bombay as judged from the analysis of 271 genuine samples are 7·62 per cent. of *Fat* and 9·57 per cent. of "*Solids not fat.*" Meggit and Mann from an analysis of 155 samples in Poona found the percentage of fat to vary from 7·06 to 7·92, for "morning" and "evening" milk, respectively. In another series of milk analysis (which is still going on at the moment of writing) I found the figure for fat in the milk of some buffaloes, to be as low as 5·5 per cent. but never below this point. The "solids not fat" were found to vary from 9 to 10 per cent. but very rarely below 9 per cent.

Average Composition of Indian Cows' milk.

The following analytical figures are from twenty-one samples of cows' milk which were collected by the Chief Veterinary Inspector of Bombay and certified by him to be "genuine." They were examined at the Municipal Laboratory as usual :—

TABLE L.

Analysis of 21 Samples of Cows' milk known to be Genuine.

(*Received from the Chief Veterinary Inspector, Bombay.*)

No.	Date.	Specific gravity at 60° F.	Total solids. %	Fat. %	Solids not fat. %
1	25–6–13	1026·6	13·86	5·0	8·16
2	,,	1027·8	14·86	5·5	9·36
3	,,	1027·9	14·46	5·2	9·26
4	,,	1028·7	16·0	6·3	9·7
5	21–8–13	1034	13·14	4·1	9·04
6	,,	1033	13·26	4·7	8·56
7	,,	1033	14·12	5·1	9·02
8	27–8–13	1036	12·51	3·0	9·51
9	,,	1032	13·86	5·0	8·86
10	,,	1034	13·45	4·2	9·25
11	,,	1033	13·45	5·1	8·35
12	,,	1032	13·21	4·4	8·81
13	5–9–13	1031	13·36	4·6	8·76
14	,,	1033	14·88	5·4	9·48
15	,,	1032	14·73	5·3	9·43
16	,,	1031	13·96	5·3	9·66
17	25–9–13	1031	13·16	4·6	8·56
18	,,	1030	14·6	5·8	8·8
19	,,	1030	14·24	5·6	8·74
20	26–9–13	1030	14·96	6·1	8·86
21	,,	1030	15·08	6·2	8·88
Average of 21 samples ..		1031	13·99	5·0	8·9

The percentage of fat was found to vary between 4·5 & 5·5, the average being 5. Only in one case (Sample No. 8) it was found to be as low as 3%. The average percentage of fat in 156 samples of cows' milk in Poona was found to vary from 4·52 to 5·34 for morning and evening milk, respectively (Meggit and Mann). It is rare to find fat below 4 per cent. in genuine milk of Indian cows. The "solids not fat" ranged from 8·5% to 9·5% the average being 8·9%, or in round numbers 9%. In

very rare cases the percentage was below 8·5 which may be taken as the lowest limit.

A word may be now said regarding adulteration of milk in Bombay. It is a notorious fact that the extent of adulteration of milk in Indian cities is far more than in European or American cities. Out of a total of 1,363 samples of milk examined at the Bombay Municipal Laboratory, during a period of five years, *only* 282 were found to be genuine. This gives 1081 or 79·3 per cent. for adulterated or watered samples of milk in Bombay. In Poona, Dr. H. H. Mann found 80 per cent. of the milk to be adulterated with water.

Milk Standards for India.

From what has been said above regarding the difference in composition, etc., between milk in India and milk in Europe and America, it is quite evident that European or American standards for milk cannot hold good for India. We shall first consider the chemical standard.

The following standard is based on the analytical results of several hundred samples of genuine milk, obtained from different breeds of animals and collected under the most varying conditions. For a routine examination, the figures for "fat" and "solids not fat" are all that is necessary to form an opinion about the genuineness of any milk sample.

Proposed Milk Standard for India.—(Chemical).

	Fat per cent.		Solids not fat per cent.	
	Average.	Lowest limit.	Average.	Lowest limit.
Buffaloes' milk.. ..	6 to 7	5	9·5	9
Cows' milk	4 to 5	3·5	9	8·5

Bacterial Standard.

The practical importance of a routine bacteriological examination of milk has been already emphasised. The first attempt to adopt a bacterial standard was made by the New York Board of Health in 1900. According to this, no milk was allowed to be sold in New York which contained over 1,000,000 bacteria per c.c. This had to be considerably modified later. Boston has a *legal standard* of 500,000 microbes per c.c. According to Rosenau the number of bacteria per c.c. in milk should never exceed 100,000. It must be remembered that conditions in America are quite different from those obtained in India, and if a standard is to be adopted for India, this should be done with due regard particularly to (1) local conditions of collection and distribution of milk, (2) *temperature* at which the milk is held, and (3) *time* elapsing between milking and consumption. In the U. S. A. the authorities insist on the milk sellers keeping their milk at a temperature not exceeding 50° F. This is impossible in India for obvious reasons. Further research is necessary before setting up a fixed bacterial standard for India. In the meantime, in the light of the results published in this paper, it is suggested that a *tentative* standard of 5,000,000

microbes per cubic centimetre may be adopted as a guide for adminstrative work.

As regards the various measures necessary for the solution of the milk problem in India, it is beyond the scope of this paper to enter into a full discussion. Mention has been already made in the Introductory Note regarding milk legislation. Other remedies besides legislation are mentioned in the "summary and conclusions" which follow.

Summary and Conclusions.

1 The milk problem in India is most difficult and perplexing. It needs for its proper solution the effective co-operation of the scientist, the practical sanitarian, the economist and the legislator.

2. The milk-supply in Bombay is partly from the dairies, milk-shops and the individual milk-vendors in the city, and partly from the suburbs in Salsette.

3. There are 48 dairies and 83 licensed milch-cattle stables in Bombay. The number of cows and buffaloes in the city is about 17,000. No statistics are available about the milk-supply from the suburbs.

4. The various factors affecting the chemical and bacterial content of Bombay milk are :—

(*a*) climatic influences, *e.g.*, temperature, humidity, etc.;
(*b*) influence relating to the milch-cattle, *e.g.*, the breed and age of the animal, time of calving, the kind of fodder, conditions of the stables, diseases of the animals, etc.;
(*c*) conditions ascribed to the *gowlees* or milkmen, *e.g.*, undesirable customs, filthy habits of life, objectionable methods of milking and of transporting the milk, communicable diseases, *e.g.*, tuberculosis, etc.

5. Three classes of milk samples were examined in Bombay :—

Class I.—Samples collected under the strictest supervision, and examined immediately.

Class II.—Samples collected with ordinary sanitary precautions, and examined after 3 or 4 hours.

Class III.—Samples collected at random, and examined after 6 to 9 hours.

6. The bacteriological examination showed widely different results according to—

(*a*) conditions of collection and transportation;
(*b*) temperature at which the milk samples were held; and
(*c*) time elapsing between milking and examination of the samples at the Municipal Laboratory.

7. The figures for microbes per c.c. and lactose fermenting organisms of the B. coli type indicate a high degree of manurial or other undesirable pollution of the Bombay milk-supply as judged from samples of Class II and Class III.

8. The results obtained from samples of Class I, demonstrate that it is quite possible to get the purest milk in Bombay, provided that proper precautions are taken regarding milking, etc.

9. Out of 614 samples of milk examined, not a single sample showed genuine tubercle bacilli, from which it may be concluded that *tuberculosis is rarely, if at all, conveyed by milk in India.*

10. Much valuable information can be obtained from a bacterial examination of milk. This is of practical importance to the Health Officer, as it affords the cheapest and most reliable means of finding out any contamination of milk.

11. The chemical composition of milk in India differs to a great extent from that in Europe or America. Buffaloes' milk which is largely used here is richer in fat and proteids than cows' milk abroad.

12. The adulteration of milk with water has reached a scandalous point in Bombay,—the percentage of adulteration being nearly eighty (80)—that is, *four-fifths of the milk supplied to Bombay is adulterated with water.*

13. Milk standards for India are essential. They must be necessarily different from those for Europe and America.

14. A fixed chemical standard for cows' and buffaloes' milk is proposed for India. This must be legalised if an efficient control is desired.

15. A bacterial milk standard for India is desirable. This should not be legalised until more work is done on the bacteriology of milk in India. A tentative standard, however, is suggested for the present as a guide for administrative work.

16. It is evident from the present investigation that Bombay milk shows an extremely high degree of adulteration and a most objectionable bacterial pollution. The only bright side of the dark picture is the well-known fact that almost every native of India boils his milk before use.

17. It is highly satisfactory to note that in connection with milk legislation, the Government of Bombay have recently passed Act VI of 1913, certain sections of which provide for the effective sanitary and legislative control of the Bombay milk-supply.

18. Besides legislation, other remedies are necessary for improving the milk-supply in India. Among these the following are suggested:—

- (*a*) an improved and efficient system of inspection of dairies, milch-cattle and stables, etc.;
- (*b*) improvement in the proper management and care of the milch-cattle. This includes better breeding and housing, provision of cheap and proper fodder, etc.;
- (*c*) education of the milkmen and other milk-dealers regarding sanitary methods of collection and distribution of milk, personal hygiene, etc.;
- (*d*) the adoption of artificial methods for purifying and preserving milk, *e.g.*, pasteurisation and sterilisation;
- (*e*) the establishment of model milk farms in the suburbs of large cities; and
- (*f*) the use of modern methods of transportation of milk from producer to consumer, *e.g.*, milk trains, motor-wagons, etc.

THE COMPOSITION OF MILK OF THE UNITED PROVINCES.

BY

MR. P. S. MCMAHAN,

Professor of Chemistry, Canning College, Lucknow.

THE data compiled in the present paper consist of two series of analyses of milk taken from cows and buffaloes in Lucknow. The first series comprises about 150 samples of milk taken from six cows and six buffaloes at the Diamond Dairy and extends over three months during the latter part of their respective periods of lactation. The second series represents the beginning of a more complete and detailed examination of the milk of nine selected cows and nine buffaloes from the Military Dairy Farm at Bibiapore which is intended to extend over the whole of their periods of lactation.

First Series.

The animals selected under this heading were all from the cattle breeding districts of Delhi and the Punjab. They were of course mostly stall fed in the winter months, their food consisting of *bhusa*, *chuni*, *khali*, etc., and of green grass in the rainy season during which the analyses happened to be made. The primary object of the series was to fix a milk standard for the United Provinces, and the samples analysed were all morning ones, which, as will be seen later, contain less fat than those collected in the evening. The data given are not intended to afford any safe guide as to the effect of external causes of environment, etc., upon the composition of milk, the investigation of which, and many contributory factors, has been left over for the second series.

Cows' milk.

With regard, then, to the average composition of the 75 samples of cows' milk detailed below, the following figures indicate a remarkably high percentage of butter fat, associated with a perfectly normal proportion of the other solid constituents as determined in the milk of European and American cows.

Table No. I.

		Limits of Fluctuation.		
Mean Sp. Gravity at 15·5°C	1·0302	1·0296	..	1·0311
Fat	5·48 per cent.	4·78	..	5·71
Solids not fat	8·78 „	8·68	..	8·94
Total solids	14·26 „		......	
Ash ..	0·700 „	0·678	..	0·724

The above percentage of fat agrees well with that found by Mann at Poona (Memoirs of the Department of Agriculture in India, Volume II, No. I), being inter-

mediate in amount between that given by the "Gir" namely, 5·2 per cent. and the "Sind" breeds, namely 6·0 per cent. In the last column are represented the lowest and highest mean percentages of the six cows selected.

The mean values for the above constants given by each individual cow was as follows :—

Table No. IA.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Number of samples	15	13	12	10	14	14
Sp. Gravity at 15·5°C	1·0297	1·0303	1·0297	1·0299	1·3112	1·0308
Fat ..	5·71	5·35	5·52	5·48	4·78	5·57
Solids not fat ..	8·78	8·68	8·75	8·76	8·78	8·94
Total solids ..	14·49	14·03	14·27	14·24	13·56	14·51
Ash ..	0·703	0·717	0·679	0·678	0·700	0·724

It will be seen from the above that the amount both of solids not fat and of mineral ash was remarkably constant, but that the mean fat fluctuated within wider limits.

An examination of the detailed analyses tabulated below discloses much wider variations in the constants, particularly in the daily fat content of the milk, and tends to show that the constants are influenced to a far greater extent by obscure physiological functions of the individual cow itself than by variations of food, climate and external environment.

This will be made clear from the following table :—

Table No. II.

Highest and lowest percentages and specific gravities.

varied from	No. 1.		No. 2.	
Sp. Gravity	1·026	1·032	1·028	1·032
Fat	4·9	6·7	3·9	6·3
Solid not fat	8·0	9·74	7·6	9·15
Ash	0·60	0·747	0·66	0·79

No. 3.		No. 4.		No. 5.		No. 6.	
1·0259	1·0315	1·026	1·032	1·029	1·0328	1·0287	1·0348
4·2	6·8	5·0	7·10	3·3	6·0	4·4	6·8
7·92	9·54	7·91	9·78	7·04	10·0	8·25	9·94
0·60	0·75	0·63	0·73	0·65	0·74	0·66	0·90

The following is a description of the six cows numbered 1—6 :—

No. 1,	Rohtak	cow,	six years old,	7th to 10th month of lactation.
„ 2,	Ludhiana	„	five „	8th to 11th
„ 3,	Patiala	„	five „	6th to 9th
„ 4,	Kasi	„	five „	5th to 8th
„ 5,	Umballa	„	seven ,	6th to 9th
„ 6,	Ferozepur	„	six „	5th to 8th

There are therefore no outstanding differences in the composition of the milk of the cows selected, but a tendency to extreme individual fluctuation of the fat content. A glance at Table No. 1A will show no evidence of an extreme variation of the fat yield of different cows, but this may very well be accounted for by uniformity of breed and of lactation period among the animals under investigation. In richness the milk appears to be comparable to that of the best Jersey cows with an average of 5·61 per cent. of fat, and is much richer than the ordinary Holstein

cows (3·46 per cent.) as determined by *Collier* in 1891. The milk of Indian cow contains an average of $1\frac{1}{2}$ per cent. of fat more than that of European or American cows, but it must be remembered that the quantity of milk yielded by the latter is very much larger.

Buffaloes' milk. A similar series of analyses totalling to about 80 were done of the milk of six selected buffaloes from Delhi and the Punjab.

The following represents the mean values obtained :—

Table No. III.

		Varying from		
Mean Sp. Gravity at 15·5°C	1·0309	1·0308	to	1·0312
Fat	7·29	6·97		7·58
Solids not fat ..	9·14	8·61		9·45
Total solids	16·43	—		—
Ash	0·739	0·717		0·758

Buffaloes' milk is characterised by an extraordinary richness in fat, the mean morning milk averaging 7·29 per cent. The other contents are also higher than in cows' milk, but to a lesser degree. So far as the mean averages of the individual buffaloes are concerned they bear pretty much the same relation to each other as the averages of the cows did.

Table No. IV.

Nos.						
Number of samples	13	12	11	10	14	13
Fat	7·16	6·97	7·23	7·57	7·25	7·58
Solids not fat ..	9·29	9·25	8·61	9·32	9·32	9·45
Total solids ..	16·45	16·22	15·84	11·89	16·57	17·03
Ash	0·717	0·733	0·736	0·737	0·758	0·750
Sp. Gravity at 15·5°C	1·0308	1·0311	1·0311	1·0308	1·0309	0·312

Here again there is a remarkable constancy among all the components, coupled with wide variations of individual analyses, as the following table shows :—

HIGHEST AND LOWEST PERCENTAGES AND SPECIFIC GRAVITIES.

Buffalo.	No. 1.		No. 2.		No. 3.	
Sp. Gravity varied from ..	1·025 ..	1·0334	1·028	1·0346	1·025	1·0334
Fat ,, ,, ..	5·3 ..	12·0	5·7	8·4	6·15	11·0
Solids not fat ,, ..	8·64 ..	9·87	8·48	9·44	7·73	9·87
Ash ,, ..	0·60 ..	0·79	0·60	0·915	0·608	0·855

No. 4.		No. 5.		No. 6.	
1·0268	1·033	1·029	1·033	1·027	1·0347
6·0	9·3	5·9	8·9	5·2	10·0
8·65	9·82	7·84	10·2	8·46	10·28
0·68	0·82	0·707	0·853	0·69	9·86

The fat varied therefore between 5·2 per cent. and 12 per cent. the latter amount and quantities approaching it being obtained in one or two cases approaching the end of the lactation period.

The empirical relation $T = 0{,}25G + F \times 1{,}2 + 0{,}14$ formulated by Richmond has been found to hold almost exactly for the mean values derived from the present series of analysis and tabulated above (Tables Nos. I and III).

The Richmond Formula.

Thus in table No. I the mean value for the total solids found analytically is 14·26 and that found by Richmond's formula (T) where F = fat and G = degrees of gravity is also 14·26.

In table III, the experimental value for T = 16·43
and the calculated = 16·62

The following table shows how the formula applies to the individual mean values obtained.—

	Cow No.						Buffalo No.					
	1	2	3	4	5	6	1	2	3	4	5	6
T (Exp.) ..	14·49	14·03	14·27	14·24	13·56	14·51	16·45	16·22	15·84	16·89	16·57	17·03
T (Calc.) ..	14·41	14·13	14·19	14·21	13·65	14·52	16·43	16·27	15·91	16·92	16·56	17·04
Error. ..	—0·08	+0·1	—0·08	—0·03	+0·09	+0·01	—0·02	+0·05	+0·07	+0·03	—0·01	+0·01

The above results give no indication of any source of constant error and therefore tend to show, given a sufficiently large number of samples so as to eliminate individual fluctuations, that Richmond's formula is perfectly applicable to the milk both of the cow and buffalo. This is further strikingly shown in certain individual samples containing widely differing solid contents. Thus cow No. 3 with 4·2 per cent. of fat on November 8th gave T = 13·05 (exp.) and calculated T = 12·85, while buffalo No. 1 on November 22nd with 12 per cent. of fat gave T (exp.) = 20·92 and calculated = 20·91. In individual samples however the divergence may amount to + 1·0.

The following is a description of the buffaloes 1—6 ;

No. 1	Rohtak	buffalo,	7	yrs. old,	7th to 10th month in milk.	
2	Jamnapari	,,	6	Do.	,,	Do.
3	Kasi		7	Do.	4th to 7th	Do.
4	Hisar		7	Do.	,,	Do.
5	Amballa		6	Do.	7th to 10th	Do.
6	Lucknow		6	Do.	4th to 7th	Do.

The difficulty of securing trustworthy information and adequate supervision of the animals under investigation decided us to make use of the facilities at the Military Dairy Farm, Bibiapore, in commencing a new and more complete series of analysis. A large stock of cows and buffaloes are kept at the farm and complete information is in the possession of the authorities of the history of each animal.

Second series.

Unfortunately for the purposes of the present paper the work has only been a short time in progress and the results obtained below, therefore, apply only to the first few weeks of the milking period. It may be of interest however to indicate the nature of the questions which the investigation is intended to answer, and to draw such inferences as may be admissible in its present initial stages.

It is proposed to investigate :—

(*a*) How the composition of the milk of each individual cow varies progressively throughout the period of lactation.

(*b*) Whether or not certain food-stuffs have any influence upon its composition.

(*c*) Within what limits the composition of milk of different cows and buffaloes vary from each other.

(*d*) What influence other characteristic variants of the animal itself, such as yield, length of period of lactation, etc., have upon its composition, and whether these in turn can be traced to external causes.

For this purpose there have been selected nine cows and nine buffaloes, morning and evening samples of whose milk are collected once a week and the results tabulated as below. A complete account of each animal is appended under the head of sections I and II respectively for cows and buffaloes.

In the table below (Table A) are given the mean analysis of cows Nos. 1—9, and in which 53 samples of morning milk have been examined, and 36 samples of evening milk. The morning milk gives a mean fat percentage of 4·325 and the evening milk 5·34 or 1·02 per cent. in excess. This is somewhat in excess of the difference found by *Mann* (loc. cit.) for "gir." cows, but it remains to be seen whether the same large difference will persist throughout the series.

1 Cows' Milk.

Furthermore, the amount of milk given in the morning was not largely in excess of that given at the evening milking so that there is here, at any rate, no relation between the quantity of milk given and its richness in fat. The solids not fat, on the other hand, were slightly richer in the morning milk.

The mean value of the 99 samples as follows :—

Fat	..	..	4·832
Total solid	..	..	13·69
Solids not fat	..	..	8·858
Sp. Gravity at 15·5		..	1·03077
Varying from 2·25	——	7·00	Fat.
7·96	——	9·95	Solids not fat.

in individual samples.

A closer examination of Table A discloses no particular relation between the fat percentage and the yield of milk. The number of factors determining the former are so many and complex that it seems impossible to eliminate the remainder entirely in tracing the effect of any individual one of them. Thus No. 5, which gives an exceptionally large amount of milk, is a cross breed of a country cow ("Harania" bred) and an Ayrshire imported from Scotland. Here we see the disturbing effect of breed on the relation. Cow No. 6 is remarkable for an abnormally low percentage of fat. On reference to the table it will be seen that this cow has a remarkably long period of lactation, amounting on the two previous occasions to 473 and 457 days respectively. Here again we have a determining factor of the first importance.

Comparing the figures on this basis, the following table is obtained :—

No.	1	2	3	4	6	7	9
Number of times in milk ..	7	2	2	4	2	6	1
Average length of lactation period.	269 days.	281	315	282	465	310	248
Average yield (lbs). ..	1·941	3·222	1·859	2·705	3·888	2·690	2 276
Average morning fat ..	4·08	4·76	5·15	4·91	2·94	4·03	4·17

In this table No. 5 has not been included on account of the difference of breeds and No. 8 of which no records have been kept. Neglecting No. 5 there remains distinct evidence of proportionality between the total yield of the cow throughout its lactation period and the fat percentage. Thus No. 6 with the

largest yield and the longest lactation period gives the lowest fat percentage ; No. 3 with the smallest yield gives the highest fat percentage. The others occupy approximately corresponding intermediate positions. It is probable that when fuller details are worked out that an even closer relation, *ceteris paribus* will be found.

Of the cows themselves, Nos. 2, 3, 6, 7, 8 and 9 belong to the "Harania" breed indigenous to the Rhotak and Delhi districts, said to be good milkers in the U. P., but poor in the Punjab. No. 4 is a "Saniwal" cow; native to the Montgomery District of the Punjab. No. 1 is a cross-bred Harania-Saniwal cow, and No. 5*a* cross-bred Harania-Ayrshire. The latter gives a much larger milk yield than any of the others.

Herewith is appended a detailed analysis of the milk of each animal, from which a good idea may be obtained of the weekly changes of composition undergone. The most characteristic feature about the series is the great fluctuation in the proportion of fat independently of the other solids which remain practically constant. These however differ slightly in each animal.

No. 1. 12 years old, Calved Nov. 11th, 1913

	Nov. 25th		Dec 2nd.		9th		16th		23rd		30th.	
	m.	e.	m.									
Fat ..	3·80	6·20	4·10	4·88	4·45	4·45	3·75	4·85	4·40	4·90	4·02	5·44
Solids not fat	9·15	7·96	8·88	8·71	8·85	8·94	9·13	8·69	8·77	8·79	8·96	8·59
Sp. Gravity 15·5°.	1·0322	1·0331	1·0311	1·0298	1·0320	1·0311	1·0336	1·0315	1·0313	1·0311	1·0308	1·0302
Yield ..	6	4			6		6	6½	4½			

No. 2 8 yrs. old. Calved. Nov. 17th, 1913.

	Nov. 25th.		Dec. 2nd.		9th.		16th.		23rd.		30th	
	m.	e.	m.				m.		m.			
Fat ..	6·0	4·2	4·8	5·5	4·53	6·4	4·60	5·86	4·82	6·00	3·80	5·86
Solids not fat .	9·95	8·91	9·44	9·65	9·28	..	9·27	8·91	8·63	9·07	9·80	8·76
Sp. Gravity ..	1·0327	1·0298	1·0302	1·0289	1·0305	1·0268	1·0327	1·0310	1·0308	1·0299	1·0325	1·0290
Yield ..	4	3	5	4	6½	5	6	5	9	7	..	..

No. 3. 5 years old, calved Oct. 5th, 1913.
dates as above.

Fat ..	5·5	6·4	4·58	5·56	4·40	6·28	5·05	6·26	5·35	7·00	5·92	6·28
Solids not fat .	9·13	8·78	9·17	8·92	9·05	8·87	8·98	8·73	9·04	8·87	9·27	8·98
Sp. Gravity ..	1·0313	1·0291	1·0312	1·0293	1·0319	1·0295	1·0330	1·0316	1·0399	1·0278	1·0307	1·0297
Yield ..	5	3½	4	3	4½	4	4½	3½	0	3½	..	..

No. 4. Saniwal cow, 9 years old, calved. Sept. 13th, 1913

	Nov. 25.		Dec. 2nd		9th		16th		23rd		30th	
m.	e.	m.	e.	m.	e.	m.	e.	m.	e	m.	e.	
Fat ..	5·15	5·3	4·45	4·90	3·80	6·4	5·66	5·90	5·17	6·90	5·24	6·07
Solids not fat	8·88	10·68	8·68	8·64	9·17	8·86	8·83	8·74	8·84	8·68	8·87	8·81
Sp. Gravity ..	1 0291	1·0312	1·0308	1·0300	1·0322	1·0289	1·0310	1·0315	1·0311	1·0297	1·0302	1·0302
Yield ..	9	7	5	7	7	7	9	5	8½	8	..	..

No. 5. Ayrshire x Harania cow, 5 years old, calved October 1st, 1913, dates as above.

Fat ..	5·00	5·10	4·53	5·82	4·00	4·6	4·5	5·2	4·3	5·47	4·49	5·43
Solids not fat .	8·56	8·50	8·51	8·67	8·21	8·38	8·61	8·54	8·34	8·58	8·85	8·79
Sp. Gravity ..	1·0291	1·0296	1·0297	1·0281	1·0295	1·0281	1·0309	1·0305	1·0293	1·0291	1·0315	1·0298
Yield ..	14	10	13½	9	..	10	13	9½	13	10	..	..

No. 6. Harania cow, 6 years, calved October 30th, 1913, dates as above.

Fat ..	3·35	3·50	2·88	3·97	2·25	4·27	2·57	3·55	2·99	4·00	3·59	3·82
Solids not fat .	8·74	8·53	8·78	8·51	8·77	8·52	8·80	8·43	8·49	8·45	8·90	8·22
Sp. Gravity ..	1·0318	1·0312	1·0319	1·0298	1·0231	1·0299	1·0337	1·0316	1·0306	1·0298	1·0312	1·0293
Yield ..	8	6	7	5	7	5	7	6	7½	5½	..	..

II.—Buffalo's milk.

The mean of the 46 samples of morning milk in table B shows a fat percentage of 5·59 and of evening milk (24 samples) 6·32, the difference between the two amounting to 0·73 per cent. The mean of the 70 samples is as follows :—

Fat ..	5·95	Total solids ..	15·35
Solids not fat	9·40		
Sp. Gravity .	1·0324		

varying from 3·85 — 7·4—Fat

8·61 — 10·53—Solids not fat, in extreme cases.

These figures compared with those of the first series indicate that buffalo's milk contains considerably less fat in the earlier stages of the lactation period than the later. The samples submitted contained 1·12 per cent. of fat more than cow's milk and 0·54 per cent. more of solids not fat.

The fat percentage appears to be considerably lower than that obtained by *Mann* and *Leather* with other breeds of Indian buffaloes, no less than three out of nine giving less than 5 per cent. The buffaloes are all of the "Murrah" breed and come mostly from Amritsar, Rhotak and the Jhelum irrigation districts.

There appears to be considerably less uniformity of composition than with the milk of the cow, and there does not seem to be the same regular relation between the fat of morning and evening milk, numbers 14 and 15 for example, gave richer morning milk than evening.

No relation could be discerned between the fat percentage and total yield during lactation at the present state of the investigation.

III.—*Mixed Herd milk.*

(*a*) *Cow's milk.*

The following analyses have been made of mixed herd cow's milk (morning) :—

	Dec. 11th.		18th.	25th.	Jan. 2nd.	Mean.
Fat	4·95	5·11	4·82	5·2	4·71	4·97
Sp. Gravity	1·03238	1·0321	1·0326	1·0325	1·0319	1·0323
Solids not fat	9·18	9·11	9·12	9·00	9·33	9·16
Ash .	0·692	0·687	0·757	0·750	0·733	0·724
Milk sugar	4·706		4·80	4·66	4·69	4·71
Proteids			3·51		3·55	3·53

The results are somewhat higher than those obtained from the series especially the total solids. The cause of this will not be revealed until the work progresses sufficiently.

(*b*) *Buffalo's milk.*

	Dec. 18th.	25th.	Jan. 2nd.	Mean.
Fat	6·71	6·45	6·41	6·52
Solids not fat ..	9·48	9·57	9·68	9·58
Ash	0·779	0·747	0·755	0·760
Sp. Gravity ..	1·0331	1·0316	1·0309	1·0319
Sugar	5·15	5·04	4·87	5·02
Proteids ..	3·69	..	3·59	3·64

The fat percentage here, although higher than that found from the series, is considerably lower than that determined by *Mann* at Poona.

Relation of Proteids, Sugar and Ash.

(*a*) Cow's milk (mixed herd).

	Sugar.	Proteids.	Ash.	Mean 13 : 9·74 : 2·0
December 11th	13		1·91	
,, 18th	13	9·50	2·50	
,, 25th	13		2·09	
January 2nd	13	9·84	2·01	

The proteids therefore appear to be a little higher than in milk of European cows, which answers to the ratio 13 : 9 : 2. On the other hand, the means of sixteen analyses of individual samples comes to 13 : 8·8 : 1·8. Further work is being done upon the subject.

(*b*) *Buffalo's milk.*

The following data have been obtained :—

	Milk Sugar.	Proteids.	Ash.	
Dec. 18th	6	4·3	0·9	
25th	6	——	0·89	Mean 6 : 4·36 : 0·91.
Jan. 2nd	6	4·42	0·93	

The ratio obtained by *Mann* was 6 : 5·2 : 0·98, showing a considerable difference in the proteid ratio. Nine samples of individual milk samples gave the ratio 6 : 4 : 0·91.

The Richmond Formula.

The following illustrates applications of the Richmond formula to the present series :—

	Mean ·w's milk	Mean buffalo's milk.	Mixed herd cow's milk. I	II	III	IV	V
T experimental	13·69	15·35	14·13	14·22	13·94	14·28	14·10
T calculated	13·63	15·38	14·17	14·29	14·07	14·60	13·76
Error	—0·06	+0·03	+0·04	+0·07	+0·13	+0·32	—0·34

	Mixed Buffalo's milk. I	II	III
T experimental	16·19	16·02	16·09
T calculated	16·46	15·78	15·55
Error	+0·27	—0·24	—0·54

Although the divergence amounts in one case to 0·5 per cent. there does not appear to be any evidence of a source of constant error in the application of the formula to Indian milk.

TABLE A.

MORNING MILK OF COWS Nos. 1—9.

No.	1	2	3	4	5	6	7	8	9	Mean.	Limits		
Number of samples.	6	6	6	6	6	6	5	6	6	53			
n Fat per cent. ..	4·08	4·76	5·15	4·91	4·47	2·94	4·03	4·42	4·17	4·325	2·94	5·15	
, Total solids ..	13·04	14·18	14·26	13·79	12·98	11·69	12·66	13·25	13·59	13·272	11·69	14·26	(13·15)
Solids not fat ..	8·96	9·42	9·11	8·88	8·51	8·75	8·63	8·83	9·42	8·947	8·51	9·42	
, Sp. Gravity ..	1·0318	1·0323	1·0313	1·0307	1·0299	1·0320	1·0300	1·0305	1·0331	1·0313	1·0299	1·0331	
Yield (lbs.)	6⅓	6⅓	4⅔	7⅓	10⅔	7⅓	4⅜	6	4	6 lbs.			

EVENING MILK OF COWS Nos. 1—6.

	1	2	3	4	5	6	Mean.	Limits.		
Number of samples.	6	6	6	6	6	6	36			
.. .. ..	5·12	5·64	6·29	5·91	5·27	3·85	5·34	3·85	6·29	
ıl solids	13·73	14·70	15·15	14·98	13·84	12·29	14·11	12·29	15·15	(12·32)
ds not fat	8·61	9·06	8·86	9·07	8·57	8·44	8·77	8·44	9·07	
Gravity	1·0311	1·0298	1·0299	1·0302	1·0292	1·0303	1·03025	1·0295	1·0311	
d	4¾	5	3½	7	9⅔	5½	6 lbs.			

TABLE B.

MORNING MILK OF BUFFALOES Nos. 10—20.

Nos.	10	11	12	13	14	15	16	17	18	19	20	Mean.	
Number of samples ..	5	3	5	6	3	6	6	6	6	2	1	46	
Mean Fat ..	4·74	4·94	6·30	5·36	6·26	6·78	4·28	6·14	5·52	Samples only.	Samples only.	5·59	
Total solids ..	13·97	14·23	15·98	14·92	15·576	16·57	13·45	15·32	15·78	..	..	15·09	[15·12]
Solids not fat ..	9·23	9·29	9·68	9·56	9·316	9·79	9·17	9·18	10·26	..	..	9·50	
Sp. Gravity ..	1·0336	1·0310	1·0341	1·0341	1·0307	1·0365	1·0310	1·0319	1·0349	..	..	1·0331	
Yield ..	7	6	5	8	5	9½	9½	9½	8	..	..	7 lbs.	

EVENING MILK OF BUFFALOES Nos. 13—20

	13	14	15	16	17	18	19	Mean.	
Number of samples	4	3	4	4	4	4	1	24	
Mean Fat	5·77	5·91	6·72	5·25	7·20	7·07	Sample only	6·32	
Total solids	15·35	15·04	16·57	14·13	15·91	16·80	..	15·63	[15·65]
Solids not fat	9·58	9·13	9·85	8·88	8·71	9·73	..	9·31	
Sp. Gravity	1·0318	1·0318	1·0380	1·0291	1·0279	1·0319	..	1·0317	
Yield	7½	4	5	6¼	5½	5	..	5½	

THE SUPPLY OF MILK TO INDIAN CITIES.

BY

DR. H. H MANN, D.SC.,

Principal, Poona Agricultural College.

THE supply of milk to Indian cities is known to be at present in a very unsatisfactory condition. Whether looked at from the point of view of the healthiness of the milk obtainable, or of the quality of the milk to be had, or of the quantity available, it is open to the most strenuous criticism. There is *no* control at present whatever in most cities,—except possibly the Presidency towns and one or two others. The act for the prevention of adulteration (Act II of 1899) in Bombay is a dead letter. And as a result of these things the condition of things must be recognised as unsatisfactory from every point of view. This would be inexcusable except for one fact which increases the difficulty of dealing with the problem. The cost of milk is already very high : anything which would increase the price, even though it made the supply a better one, would but increase the difficulty of getting it to those people of the poorer classes who are at present suffering most from the present conditions. At every point, in every proposed method of dealing with the matter, one is met by the difficulty of controlling, of improving the supply without increasing the cost,—for, and I repeat it, if a remedy involved a material increase in the cost, it would be perhaps be worse than the disease.

To show exactly where we stand, it would perhaps be best to give a description, obtained from data collected, much of it, specially for this paper, of the present supply of a city, namely, Poona. It is typical of many other places : the difficulties which surround the problem here are those which are found elsewhere : and it is probable that a thorough appreciation of the present position may at once lead to a clearer understanding of the methods which are feasible to improve the situation.

Poona City contains according to the last census a population of 117,256. Its population is a fairly representative one, save that perhaps the so-called higher classes are in slightly greater numbers than usual. There is a limited amount of manufacturing industry, but Poona cannot be called a factory town. It lies in a district which is dry, almost semi-arid, except where irrigation occurs,—but both above and below the city there is a large area watered and irrigated by the Mutha Canal extending from eight to ten miles above the city to fifteen miles below. Irrigation from wells is frequent in the country round,—and that this country is adapted to the production of fodder is seen by the train loads of *lucerne* which are sent to Bombay every day for feeding horses.

The city like all others is partly supplied from milk animals kept in the city and partly from milk brought in from outside. I will deal with the latter source

of supply first, and am able to give figures obtained from an actual census of the amount brought on two days into the city boundaries. There are fifteen entrances to the town, and the milk is brought from no less than forty-seven villages.

The actual supply brought in in one day amounted to 5,560 pounds, almost all of which was brought in by hand and, in a few cases, by bullock cart. The train was only used for the milk from three villages,—and the amount brought only amounted to 120 pounds. For the remainder the milk came as follows :—

From villages three miles or less from the centre of Poona	1,168 pounds or 21 per cent. of the total.
From villages from three to six miles from the centre of Poona	2,688 pounds or 48·3 per cent. of the total.
From villages from six to nine miles from the centre of Poona	1,532 pounds or 28·5 per cent. of the total.
From villages over nine miles from the centre of Poona (by train)..	120 pounds or 2·2 per cent. of the total.

It will be seen, therefore, from how restricted an area Poona City draws its milk supply. It is practically all brought in from the immediate neighbourhood, the railway is not used to any appreciable extent, and the means of bringing it are of the crudest.

As already stated, it is usually brought by hand and generally in brass pots slung over the shoulders of the milk men, or carried on their heads. The number of people engaged in this work, and for many of them it must mean the loss of at least half a day, is 351, and the average amount brought per man is only 16 pounds. It is evident, therefore, that this portion of the Poona City supply is brought and distributed in an exceedingly uneconomical manner, and involves a very large waste of labour without any corresponding advantage.

But what of the price and quality of the milk thus brought into a city like Poona ? In the first place, by far the largest amount is buffaloes' milk. Out of the animals supplying the milk, in number 956, only 178 were cows,—and taking the yield of a cow in the Deccan at 5 pounds and of a buffalo at 10 pounds of milk per day, this would indicate that only 8½ per cent. of the milk brought into the city is provided by cows, and the remainder by buffaloes. This indicates the extent to which even in the Deccan, the buffalo proves itself *the* milking animal of India.

Bought at the entrances to the City, the price varies with the quality. The result of all my previous investigations would indicate that for such cows as occur in the Deccan, all genuine cows' milk contains at least 3½ per cent. of fat and 8½ per cent. of other solid matters (" solids not fat "), while the corresponding figures for buffaloes' milk are 5 per cent. of fat and 9 per cent. of other solid matter. These figures are, in fact, exceptionally low, and ninety per cent. of actual genuine samples will be far richer than these figures show. In determining the number of adulterated samples, I have allowed all samples to be genuine which, even on this basis, showed less than ten per cent. of water added. On this basis, out of fifty-one samples collected at the entrance to the city, only ten were genuine or less than twenty per cent., the remainder were adulterated with more than ten per cent. of water. The amount of adulteration varied with the price charged here, as well (as we shall see later on) in samples bought at shops in Poona City. Of samples bought—

(1) at 4 seers (8 pounds) per rupee, all were genuine.
(2) at 5 seers (10 pounds) per rupee, sixty-four per cent. were adulterated with water, and the average amount of water added was *twenty-nine parts* to 100 parts of genuine milk.

(3) at 6 to 7 seers (12 to 14 pounds) per rupee, fifty per cent. were adulterated with water, and the average amount of water added was *forty-seven parts* to 100 parts of genuine milk.

(4) at 8 to 9 seers (16 to 18 pounds) per rupee, ninety-two per cent. of samples were adulterated with water, and the average amount of water added was *seventy-two parts* to 100 parts of genuine milk.

(5) at 10 seers (20 pounds) or more per rupee, all the samples were adulterated with water, and the average amount of water added was *one hundred and seventeen parts* to 100 parts of genuine milk.

Thus the close connection even before the milk reaches the city between the price and the amount of water added is evident,—and the fact of the almost general adulteration of samples now brought from outside seems proved.

We are in fact able to conclude that at present, in so far as Poona is a typical city, that—

(1) the milk brought from surrounding villages for city consumption is almost all brought in small quantities and carried by hand,

(2) this milk is adulterated with water in the case of practically eighty per cent. of what enters the city,

(3) the amount of water added varies very closely with the price at which the milk is to be sold,—and there is not even an even chance of getting pure milk if more than six seers (12 pounds) of milk are obtained per rupee, while the cheaper milk contains already more than its own volume of water. This is at the entrance to the city, before the retailers' profits are added and retailers' adulteration occurs.

In one matter I have been rather pleased with the condition of the milk,—namely, in the amount of dirt it contains. This is not nearly so great as would have been expected, and does not show the addition of quantities of dirty water. The dirt being determined by 'Gerber's dirt tester,' I have divided the milks into four classes, and the results of examination of fifty-one samples are as follows :—

Clean, or nearly clean samples	56·7
Fairly clean samples	33·3
Distinctly dirty samples	7·8
Very dirty samples	1·9

But after all the milk brought into Poona City only forms a portion, and not a very large proportion, of the milk consumed there. A much larger quantity is obtained from animals maintained in the city itself, and for information with respect to this, I am indebted to a census of cattle taken by the City Health Department some time ago,—as well as to inquiries by my own assistants.

According to this census, there were *2,688* milking animals kept inside the city, of which *1,532* or 57 per cent. were kept for private use only, and *1,136* or 43 per cent. kept for sale of the milk. I do not propose to refer further to the former class, except to note that among these animals kept for private use by far the larger proportion were cows and not buffaloes,—these amounting to 73·5 per cent. of the total number so kept. This probably arises from the fact that a cow is much more easy to attend to than a buffalo, and can usually be tended by a member of the household. A buffalo, on the other hand, requires a servant, as not only is its feeding more troublesome but it has to be taken out every day, and requires far more thorough washing. But it seems nevertheless from the preference for it by milk sellers, that the buffalo is found to be a more profitable milking animal.

Among the animals kept for the sale of their milk (*1,156*) 224 or 19·75 per cent. were cows, and *932* or 80·25 per cent. were buffaloes.

The sheds in which they were kept were distributed all over the city, were mostly very small. Over eighty per cent. of these sheds had less than ten animals, and over fifty-five per cent. had less than five animals. They were situated in all sorts of positions, without any control. Nearly six per cent. were under a dwelling-house ; over six per cent. were either *in* a dwelling-house or on the verandah of a dwelling-house : over fifteen per cent. were attached to and continuous with a dwelling-house, while sixty-three per cent. were in the compound of a dwelling-house. Though the pavement of the milk sheds was good (being made of stone) in thirty-seven per cent. of cases, yet the remainder were very bad. No pavement whatever existed in over thirty-two per cent. of sheds, and in sixteen per cent. it was so bad that it might as well have not been present. So far as these two classes of sheds are concerned, they are abominably insanitary, the urine sinks into the ground and remains there. The sheds, too, are overcrowded. Allowing six feet as the necessary length for an animal to stand, the width allowed in the shed for each animal is only 3½ feet in three per cent. of cases, less than five feet in 14 per cent. of sheds, and less than 6½ feet in twenty-three per cent. further of the sheds.

The milk produced by these animals can only be estimated, but taking the same rate of production as has previously been suggested (5 pounds per cow and 10 pounds per buffalo per day), the amount available from animals kept in the city will be—

Private Sheds.

Cows	1,126 at	5 pounds.—	5,630 pounds.
Buffaloes	406 at	10 „ —	4,060 „
			9,690 pounds.

Sheds for Sale.

Cows	224 at	5 pounds.—	1,120 pounds.
Buffaloes	932 at	10 „ —	9,320 „
			10,440 pounds.

This gives a chance of estimating the total daily supply required by a city of the size of Poona, and if the above figures be added to those of the milk brought in from outside, the amount comes to 25,690 pounds ; of this 21·25 per cent. is obtained from outside sources, 37·72 per cent. from animals kept by householders for their own use, and 40·63 per cent. from animals kept by *gowalas* in the city for the sale of the milk. This gives an idea of the problem which is before anyone who wishes to improve the milk supply of a large Indian city.

We have now to consider the organisation for the sale of milk. There is one regular milk market (Jogeshwari), where all outsiders who bring milk for general sale are found, and where retailers congregate to purchase this supply. By the time it is exposed for sale here the milk has become dearer, and has also become more adulterated. We purchased only ten samples here, but they were obtained in several days, at prices varying from four to nine seers per rupee—

(1) One sample was bought at 4 seers per rupee and was genuine.

(2) Three samples were bought at 5 seers per rupee : two of these had water added, the average amount being sixteen per cent. of the original milk.

(3) Three samples were bought at six and seven seers per rupee : all were adulterated, and on the average the milk as sold consisted at least to the extent of one-half of added water.

(4) Three samples were bought at eight and nine seers per rupee : all were adulterated, and on the average the milk as sold contained 135 parts of water for every 100 parts of original milk.

The chance of adulteration, therefore, and the quantity of water added varies almost exactly with the price,—and even at the wholesale milk bazaar in the city, if more than 4 seers (8 lbs.) of milk are obtained per rupee there is an almost absolute certainty that pure milk will not be obtained.

When we come to the milk as retailed in the shops in Poona City, the state of things is still worse. Here, even if the very high price of four seers per* rupee is paid there is no certainty of getting pure milk. Even at this price out of nine samples obtained only six could be passed as pure even with the exceedingly low standard we are setting up. Of the others, thirteen parts of water were added on the average for 100 parts of milk. If the price is lower, the adulteration becomes a certainty. At 6 to 7 seers per rupee there is, on the average, 47 parts of added water for every 100 parts of milk ; and at 8 seers per rupee, there is no less than 92 parts of added water for every 100 parts of milk.

I am able to get an idea as to whether the condition of things is getting worse or no by comparing these results with those obtained by one of my assistants (Mr. S. R. Paranjpye) in Poona City in 1911. He then found the results indicated in the following table :—

	Price, 4 seers per rupee.	Price, 5 seers per rupee.	Price, 6–7 seers per rupee.	Price, 8 seers per rupee.
Number of samples taken	1	2	5	18
Genuine samples	1	..	2	2
Adulterated samples	..	2	3	16
Water added for 100 parts of pure milk ..	..	23 parts.	49 parts.	37 parts.

It would seem evident that while adulteration is no more general than two years ago, yet it is more shameless, and the quantity of water added for milk of the same price is much more than it was previously. In other words, *pure* milk *is* rising in price very rapidly, and the probability of getting pure milk at any particular price is getting less.

I may now summarise my conclusions with regard to the present condition of city milk supply of Indian cities, so far as they are illustrated by experiences in Poona, considered as a typical city.

(1) The milk supply is partly (to the extent of about one-fifth) brought from the outside of the city. This amount is drawn from the immediate neighbourhood and is almost all brought in by hand in small quantities.

(2) The remainder is produced inside the city,—partly by animals kept in or in connection with houses, for private use only,—and partly by animals kept for the most part in unsatisfactory and insanitary small sheds.

(3) Except for the animals kept for private use, about *ninety* per cent. of the milk is produced from buffaloes.

* It may interest those acquainted with the milk trade in England to note that 4 seers per rupee is equivalent to nearly 2¼*d.* per pint.

(4) The milk as it enters the city from outside is already very largely adulterated with water,—the adulteration varying with the price. No milk costing less than 4 seers per rupee can be expected to be pure.

(5) The milk as obtainable in the city itself is adulterated to a still greater extent. Again no milk bought at a lower price than 4 seers per rupee is likely to be pure,—while it is practically certain that all milk costing 6 seers per rupee or less will be adulterated.

(6) The practice of adulteration is increasing in shamelessness, the amount of water added is greater and greater,—as the price of pure milk tends to rise.

(7) The dirt in the milk is not so great as would be expected from the insanitary and dirty conditions under which the milk is produced.

Such being the conditions of the milk supply at present in Poona,—and there is no reason to suppose that the conditions would be materially different in other big cities,—the question at once arises as to what can be done to deal with the situation both as a piece of sanitary improvement, and as an agricultural problem.

From a sanitary point of view what we want to do is to ensure—

(1) That the cattle—cows or buffaloes—giving milk are healthy. Of this there is no control whatever at present.

(2) That they are kept under sanitary conditions. For the animals inside the city I have shown that this is not the case now, and there is every evidence that the conditions in the villages from which the milk comes are no better, except for the fact that there is plenty of fresh air.

(3) That the milk should be in good condition when delivered to the customers. The milk is delivered only once a day, and hence has to be kept without pasteurisation or other method of preserving, in a hot climate for many hours.

(4) That the milk should not be mixed with water or creamed before sale.

(5) That the arrangements for bringing to market should be such as to prevent the milk becoming dirty, or liable to be infected with objectionable materials.

This represents only one side of the question. From an agricultural point of view we want to find out the most economical method of meeting the large demand for milk from our cities, and placing it at their disposal at the cheapest rate possible. Once more I would state that in my opinion the question of price is vital.

Any attempt to impose sanitary measures which will result in a rise in price of pure milk will be a mistake, and the problem is to find a method of so economising in the production of milk, and in the method of its conveyance to market, that it will be possible to impose restrictions in the interests of sanitation without raising the price.

Is this possible ? I think it is, judging by the experience of the last few years here, and by the experience of almost all other countries in which the dairy industry is highly developed. I shall not be able in this short account which follows to give all the reasons for the positions I put forward, but the evidence is available.

In my mind, three things are radically wrong with the present milk supply as illustrated by Poona, and which lead to the production of a very bad supply at a very high price.

(1) The animals which are used for milk supply are subject to defects both in the case of cows and buffaloes. In the case of cows, they are not produced for milk, but are in most cases incidental in the production of a

breed of working cattle. In the case of buffaloes, though they are primarily produced for milk purposes, the number of really good milking animals or milking strains is decreasing,—and such animals are not obtainable now at all easily. In other words, the amount of milk produced by the animals used is very small for the amount of food consumed.

(2) The animals are kept, in large proportion, where they ought not to be kept, namely, inside a big city. They are there, in very expensive quarters, under almost necessary insanitary conditions, where all the food has to be carried to them,—where it is in many cases necessary, for economy's sake, to slaughter them when they become dry,—simply because of the difficulty hitherto felt of carrying milk in good condition from any considerable distance. This difficulty can be got over, and, if this is true, milk can be delivered in Poona, as in most other large cities from animals kept outside more cheaply and in a purer condition than by the present arrangements. It seems to me essential to take the cattle out of the cities,—and to arrange to transport milk.

(3) The milk already produced outside is transported to the cities in the crudest, the most expensive and almost the most insanitary manner possible. If the bringing of the milk from villages to the cities can be organised, it can be cheapened, more can be produced by the same people who are now producing it, and better milk will be available in the city.

It seems therefore of vital importance, if the milk supply is to be improved—

(1) That the animals should be improved so as to give a larger amount of milk for the food employed.

(2) That the animals should be in cheap and natural surroundings outside the city instead of inside.

(3) That the transport of milk both from adjacent points by road, and from distant points by railway, should be organised, so that cheaply produced milk should be delivered in the cities in good condition.

With regard to the first of these points, namely, the production and use of a better animal, the difficulties are perhaps greatest, and will take long to solve. For the present, all a dairy owner can do is to take the best breed available, whether of buffaloes or cows, and the best animals among them with the best of male animals for the herd, and ensure that the best is got out of these animals by suitable feeding.

In connection with the development of better animals than are in use at present, my colleague, Mr. J. B. Knight, who has had large experience, has recently expressed himself as follows :—

"The development of a profitable dairy animal from any of the types existing without outside blood is the work of generations, working on scientific principles, consistently, intelligently, and persistently. The agency for effecting this is difficult to point out. The necessity for continuity in this work is so great, that it places it beyond the scope of Government Institutions, because of the necessary frequent changes of personality. The only agency which could undertake this work, with a reasonable expectation of accomplishing marked results does not evince any great interest in work of this character. We refer to the Hereditary Chiefs and Sardars,

who have estates adapted to the work, and who, if they were really in earnest, could carry on this work from father to son, along fixed lines and accomplish something. If the above noted gentlemen could be aroused to form breeders' associations and definite ideals laid down, and authentic records of breeding and production kept, some noticeable improvement might begin to appear in 10 or 15 years."

Till such time as this is done it will be a question of utilising the best of the existing milk breeds and milk animals. That even among existing breeds there are very great differences is shown by the following figures from the records given me by [illegible]ight :—

Breed of Animals.	Average yield of milk per annum.	Average yield of best animals.	Maximum yield per annum.
Sind Cows	about 2,000	about 3,500	4,700
Kankrej Cows (Gujarat)	„ 2,000	„ 3,500	4,265
Gir Cows	„ 2,000	..	3,687
Jafferabadi Buffaloes (Poona records)	..	3,500	5,438
Delhi Buffaloes	3,000	..	6,000 to 8,000
Surti Buffaloes	2,780	..	5,034

The Deccan breeds of both cows and buffaloes give a much less quantity than this per annum.

The question of getting the largest amount of milk from animals kept is largely connected with suitable and regular feeding. Such feeding is very rarely done at present. There is hardly ever any arrangement for the regular growing of succulent fodder, and for its provision in the form of silage during the drier seasons of the year. Without this the best will never be obtained from the cattle kept,—and the milk supply, if it is to be in the greatest quantity and best quality that the animals can produce, must be obtained from a situation where this regular feeding is possible, where growing and storage of succulent fodder can be made, and where the animals can utilise it best in the production of milk. If we look on the animals, as we ought to do, as simply milk-making machines,—the cost of the fodder for each pound of milk produced becomes the vital consideration in the economic success of milk production. At present I am convinced that the production is not economic,—because animals are used giving very little milk, and the feeding is not such as to lead to their giving the maximum amount of milk.

Again, the animals should be in cheap and natural surroundings away from the city. I would do everything to encourage the growth of country dairies or of the keeping of cattle, for milk supply to towns, in villages,—and everything to discourage the keeping of cattle for commercial milk production in the city, at least when a satisfactory supply from outside is arranged for. I think that the provision of municipal sheds for milk cattle, and all such arrangements, while they may be necessary in certain cases to ensure sanitary milk at all at present, are essentially a move in the wrong direction. The object should be to get the cattle removed away from the city entirely, and transport the milk.

For villages or, in fact, for centres of milk production either near or far, the chief question seems to be the organisation of the supply either by large dairies, or by co-operative arrangements for collecting and transporting the milk.

There has been much talk in the last two or three years about the organisation of large dairy companies for the supply of cities. Such large dairies are likely to be successful if located suitably on cheap land with regular water-supply,—with good railway (or road, if near enough) connection to the market,—and if good animals are kept. As an illustration of what can be done in this direction, I may note that the Military Dairy in Kirkee can now and does now place milk in Bombay and sells it at a profit, at a rate of 2 *as.* per *pound.* This is of course done because it is a large concern, with well selected animals with excellent feeding arrangements, including the regular use of silage when green grass is not available, and with pasteurising and cooling arrangements to ensure that no milk goes bad. With the perfecting of pasteurising, there is no need for such a dairy to be near the city supplied, provided there is a good railway connection ; it can be located wherever say within a hundred miles, milk production will be the cheapest and most successful.

Apart from the establishment of large dairies as just suggested, the only method of ensuring a pure milk supply at a cheap rate is the organisation of village production and transport. It always seems to me,—and it really is,—a great pity that such a large amount of labour should be employed in merely taking milk to market, which could be used in tending more animals and producing more and cheaper milk. The whole is a matter of gaining the confidence of the village cow-keepers and then their organisation. The winning of their confidence is a thing for which no rules can be laid down, but it is an essential preliminary to the organisation of the supply,—either by a middleman who buys it in the village, or better by a co-operative organisation of the milkmen themselves.

I only know one such co-operative organisation in India at present,—at Benares,—and the account of this (which I owe to Mr. Ewbank, Registrar of Co-operative Societies) illustrates its possibilities and also its difficulties. I will quote the account of this by the Registrar of Co-operative Societies, United Provinces, and then give a summary of its accounts for the last half-year of 1912. In this account a ' Ahir ' is simply a cow owner.

" The Vishweshwar Co-operative Dairy at Benares is an institution started and owned by Ahirs and not by capitalists. To remove at least partially the great complaint about the impure milk supply of the town, the idea of starting a dairy to supply pure and fresh milk was suggested to the Ahirs and some of them took it up. They organised the business with the help of Babu Shiva Mohan Lal, Inspector of Co-operative Societies. A manager was appointed to work under the guidance of a committee of Ahirs who elected Babu Moti Chand, a leading resident of Benares, as their President.

" The society was registered in June 1911. The shareholders are almost exclusively the Ahirs and they have paid Rs. 354 in shares so far. They will continue to buy shares from their savings. No other capital is employed if we exclude the cash credit of Rs. 100 which the Benares Bank has sanctioned and the amount borrowed to build sheds. Sales are made for cash and the sale-proceeds are enough to meet current expenditure and leave a margin for profit. The manager keeps the accounts. There is also a credit branch for advance of loans to the Ahirs.

" The dairy management purchases milk from the individual shareholders (the Ahirs) at ten seers for a rupee. The feeding of cattle and the milking is conducted in the presence of the manager, the headman of the Ahirs, and some servants. The milk is collected in cans, locked up by the manager and carted to the city in charge of the salesmen. The cans have pipes attached to them ; the contents can be taken out, but nothing can be poured in. One horse cart and one ekka are at present

employed for cartage. They take the milk morning and evening to the five shops which have been opened in the various quarters of the city and the milk is sold there to the general public. The rate is eight seers a rupee. Shops have been taken on rent and one salesman works at each shop. The manager goes out from time to time to see how they work and to attend to complaints. There is a great demand for the milk. The crowd at the shops is sometimes as large as at the third class booking offices in large railway stations.

" The dairy is situated outside municipal limits, about four miles from the centre of the city. A plot of land was taken in the beginning on lease and is still in occupation. An opposition set in soon after on behalf of vested interests; the other Ahirs and professional dealers left no stone unturned to discredit the organisation and to injure it. They spoke to the owners of the shops to eject the salesman, and also to the landholder and his agents not to allow any more land to the dairy. Shops had to be changed or rents raised and the servants of the landholders had to be propitiated. On one or two occasions some Ahirs armed with lathis came to threaten the salesmen at the shops. The landholder and his tenants raised difficulties when they were approached to give some more land for extensions. In this matter the aid of the district authorities was sought through the Registrar of Co-operative Societies and they settled reasonable terms with the landholder and the occupancy tenants. One tenant is still objecting. This is about the only matter in which help has been given by the authorities. No help has been given by the municipality.

" The success of the dairy was soon noticed. People thought there was a good deal of profit and hardly two months were out when a rival shop was opened in the immediate vicinity. In this case some men combined to buy milk from the Ahirs in the city and put them in cans similar to those of the dairy, rented a shop adjoining the dairy shop and brought the milk there for sale. As they had not to traverse any distance they often managed to reach their shop earlier and customers who did not like to wait bought from them. They had also a comparatively small quantity to sell. The rival shop is now on the decline. A capitalist however who had his dairy at Calcutta and who could not make it a success there is shifting to Benares and some of his cattle have already come.

" The management has found from experience that there is not much profit in this business if it is run on modern lines, but that it can pay its way. In Benares specially even well-to-do people are not willing to pay a little extra price for good and pure milk. The dairy has three ponies and it had to pay on account of their feed, treatment, occasional breakdown and hired labour Rs. 900 during the last year for transport. There were also occasional surpluses of milk, which resulted in loss. Dahi or butter is generally made of the unsold milk but they yield much less profit than milk. The surplus is occasional, so it will not pay to engage a permanent establishment to deal with it. An attempt was made to sell the extra milk to sweetmeat-makers at a slightly reduced rate, but they are somehow in opposition and are determined not to give any help.

" It has also been found that the best customers are the common people who buy for cash and give no trouble. Formerly the manager made it a point to supply to public institutions and rich men, but delays, deferred payment, the question of commission to servants, etc., came in the way and he has now definitely given up the practice. The manager has also hitherto failed to solve the question of a house to house supply, for Benares is peopled mostly in lanes through which no carts can pass. A sufficient number of customers living in one locality has also not come forward to pay the extra cost of labour.

"The dairy has about 100 head of cattle of which about 30 are dry. There are more buffaloes than cows. The outturn of milk now is nine maunds per day, but the quantity goes down in the summer."

Of course this is only a small concern: there are some groups of villages near Poona, for instance, where a larger society could probably be organised than that of which I have spoken. This Benares Society works, however, on a very narrow margin of profit. Its accounts for July to December 1912 showed a gross profit on the sale of 120,700 pounds of milk, of Rs. 1,395 and the nett profit was Rs. 235.

Perhaps this is not a *brilliant* success,—but it sells pure milk at 8 seers per rupee in Benares,—a price at which pure milk is *never* obtainable in Poona.

This organisation of milk production away from the cities, and of transport to the cities does not seem beyond possibility in Western India, whether by large dairies, or by the utilisation of village supply. Exactly the mechanism for doing it will have to be worked out. Neither the data nor the means are available for giving details of such a mechanism. But every evidence exists to show that it can be done.

When it is done, then the time will have come to apply strictly sanitary rules with regard to the milk cattle sheds inside the city, to the quality of milk sold in the streets or in the shops, and generally to bring the milk supply under the sanitary control which is so very essential. Till such organisation has been shown to be workable, without raising the price of milk, then I fear that the supply as at present arranged cannot be interfered with. It is a great pity that this is the case, but anything which tends to raise the present very high price still further would defeat its own object.

In conclusion, I have tried to show the deplorable condition of city milk supply at present in Western India, the difficulties in improving it, and the methods which seem to offer the most hopes of success. The position is by no means hopeless, but it is difficult; the data I have put forward will, I hope, lead to a wide discussion of the subject, and to the improvement of one of the very worst conditions in city life in Western India at present.

MILK SUPPLY.

BY

THE HON'BLE MR. MERWANJEE COOWASJEE,

Member, Municipal Committee, Rangoon.

The control of the food and water supply forms at the present day one of the most important items of the work of those who are responsible, either officially or in their capacity as Municipal Commissioners, for the health and well-being of the public, and I think it must be admitted that all those interested in or connected with Sanitary Science fully realise their responsibility and the necessity of this particular branch of their work.

It was only when water was proved to be a source of danger through becoming contaminated with disease germs that authorities decided, and very wisely so, that public water supplies derived from sources free, or as free as possible, from pollution, were necessary. The public have now been educated so far in this direction that legislation to control and preserve their water supplies from contamination is eagerly sought for and obtained.

In the case of meat also, the necessity for public abbatoirs and inspection of animals before slaughter, and of the meat afterwards, is now becoming fully recognised, and is already in practice in most large towns in India.

Up till recently, however, the question of the milk supply had not received that amount of attention it deserved. In Western countries this is being very rapidly remedied, but in India the question of the control of the milk supply is admittedly unsatisfactory. In Western countries milk forms a very small item in the daily food supply of the individual after the period of infancy is passed, but there is no country in the whole world in which milk forms such an important article of diet as in India. It seems to me, therefore, that it is of paramount importance that milk supply should be placed on the same footing with regard to its control, as the water supply.

I do not propose to attempt to discuss the subject of the milk supply from a scientific point of view. There are many scientific gentlemen who probably will deal with the subject from that point of view, but I desire to touch on one or two points which have occurred to me from what I may describe as an administrative standpoint.

It is admitted that some change, and very radical change, too, is necessary in the control of the milk supply, owing to the fact that some diseases are communicable by its agency, and also from the fact that it is an article which lends itself easily to adulteration.

I am glad to note from the perusal of a paper by Dr. Newell which was read at the last Conference, that compared with Western countries tuberculosis is comparatively rare in Indian cattle and that in endeavouring to obtain a wholesome supply of milk in this country we have not to deal with large tubercular herds as has been found to be the case in European countries.

Tuberculosis exists to a large extent in milk cattle in England, but up to the present year it was only dealt with officially when found existing in the udder, and under the Contagious Diseases Animals Act, milk from a cow with a tubercular udder was prohibited from sale. A very important Act known as the Tuberculosis Order, 1913, has now been brought into operation under which cattle found suffering from tuberculosis, and so certified by a qualified and duly appointed Veterinary Inspector, are slaughtered, and compensation according to the value of the animal is awarded to the owner.

If therefore it is an established fact that tuberculosis is a comparatively rare disease in India, the very important question of expense in stamping it out and giving compensation to the owners of diseased cattle considerably reduces the difficulty of dealing with the milk supply, which to my mind resolves itself more into a question of educating the *Gai-wallah* into cleanly habits, and the necessity for more sanitary arrangements in and around the sheds in which the cattle are kept.

I have before me a report on the milk supply of Rangoon which was submitted some years ago by the Municipal Veterinary Officer, Dr. A Blake, F.R.C.V.S., D.V.H., in which the cattle supplying the milk to Rangoon are fully described, and they appear to me to coincide very much with the conditions existing in other large towns, as I know from personal acquaintance and from perusal of some papers which were read at the last Conference.

I may here note that throughout Burma the milk trade is entirely in the hands of the natives of India, and they have introduced their custom of keeping cattle in insanitary surroundings as they were probably brought up to do in their mother country.

I do not wish in any way to disparage the natives of India in comparison with the Burman, who would probably keep his cattle no better, but simply to show that whether it is in Burma or India, we have the same class of people to deal with, a class utterly ignorant of the first principles of cleanliness or sanitation, and who will probably oppose any efforts on the part of the authorities to introduce them until they have learned from experience that it is to their own interests in the improved health and condition of their cattle to do so.

The Burmese have never taken to milk as an article of diet and consequently Burmese cattle have never been used for milking purposes. They are to all intents and purposes in a state of nature, that is, providing a certain quantity of milk for the sustenance of the young calf when it is born and until the latter is able to pick up its own food.

There is no doubt that any improvement in the general conditions of keeping milk cattle, which is apparently necessary before any improvement in the milk supply can be expected, must be accompanied by a considerable expenditure of money which would either severely handicap the trade or raise the price of milk to an almost prohibitive extent.

From my experience of those who carry on this business and make their living by selling milk, I do not think that they are in a position financially to provide sanitary cow, sheds without some assistance. It is difficult, of course, to know the circumstances which apply to all the towns in India, but from what I can

gather, the majority of milk of almost all large towns is now derived from outside municipal limits. This is, at any rate, the case in Rangoon. Let us consider for one moment the conditions under which these people live. They are simply squatters on Government land and naturally their object is to build sheds at as little cost as possible. They have no long lease of the land, and it is therefore not to be expected that they will spend any considerable sum of money in providing their cow-sheds with pucca floors and a good water-supply, which after all appear to be the most indispensable and necessary requirements in this country in the sanitation of cow-sheds.

Speaking from experience as a Municipal Commissioner in Rangoon where we have a large stud of working bullocks and also extensive cattle lairages attached to both the slaughter-house and the cattle market, I am in a position to say that it is practically impossible to provide an impervious floor without spending a considerable amount of money. I know that it is easier to provide a suitable floor for milking cows than for working bullocks owing to the urine being voided in a different manner. It seems very necessary then that if we insist on sanitary, cow-sheds, we must be prepared to recommend :—

(*a*) That the sheds should be built by the local authority and let out to the cow keeper at reasonable rent, or that substantial assistance should be given in the shape of an advance if the cow keeper is prepared to build these sheds himself.

(*b*) That a tenure of the land should be so arranged as to make it worth their while to spend money on these sheds.

(*c*) That a certain amount of grazing ground should be reserved for these cow keepers which will not be used up for any other purpose.

As an argument in support of this, I should like to draw attention to the enormous amount of tinned milk which is imported into India. Through the kindness of Messrs. Nestle and Anglo-Swiss Condensed Milk Coy., I have been enabled to obtain the total imports of condensed milk into India through Bombay, Karachi, Madras, Calcutta, Chittagong and Rangoon for the last six years, which are as follows :—

1907-08	 7,173,139	lbs.
1908-09	 8,218,919	"
1909-10	 9,198,423	"
1910-11	 9,855,791	"
1911-12	 11,232,310	"
1912-13	 12,783,299	"

From this table, it will be noticed that in this period of six years the amount has practically doubled and now reaches the enormous total of 5,757 tons during 1912-13.

This is a matter which I think calls for serious consideration, and, whilst fully admitting the advantage to the inhabitants of this country in obtaining such a supply of milk, it appears to me to be economically wasteful, and a matter which calls for immediate attention from the agricultural authorities.

I admit that there are, unfortunately, diseases occurring in this country, such as cattle plague, anthrax, and foot and mouth disease, which periodically play havoc amongst the cattle population causing large mortality, but the ravages of the former, *viz.* :—cattle plague, have been greatly reduced by the employment of serum inoculation through the medium of the Civil Veterinary Department. It cannot be denied, however, that India is essentially an agricultural country, and one

which, despite these diseases, is fully able to produce all the milk that is required for its own consumption, and I even look forward to the day when it should be able to export to other countries.

It must be borne in mind that all agricultural operations in this country, such as ploughing, etc., are done by bullocks, and that therefore there is an additional incentive for the rearing of cattle, for whereas in other countries the bull calves are practically worthless, in this country they form a very considerable asset when grown into mature animals.

There are some customs deeply ingrained in the minds of cattle keepers peculiar to this country, which add a certain amount of difficulty in dealing with cleanliness in and around cattle sheds, which have not to be contended with in Western countries. One is the keeping of all sorts and conditions of cattle together, and not separating those actually in milk from those which are dry, and from the young cattle. If this is not to continue it naturally means that much larger expenditure on sheds is necessary. In the Report by the Veterinary Officer, Rangoon Municipality, already referred to, I notice that he suggests the provision of milking yards in and around the areas in which milk is produced. The whole of the process of milking would be carried out in these yards, and of course only those cows that are in milk would be brought into them, the milk would then be conveyed into the towns in proper cans, thoroughly cleaned beforehand.

The other custom I refer to which militates against cleanly milking is that of always keeping the calf with the mother. It is probably well known to all of you that in this country cows will not give their milk freely, in fact, most lose their milk altogether unless their calves are with them, and no doubt most of you have seen the devices which are resorted to, such as stuffing the skin of the dead calf when from accident or disease it has died, to prevent the cow from becoming dry.

These are matters which I think the Agricultural Department of this country should endeavour to improve by educating the people, and though it may take a long time to break down these old established ideas, we may hope that at some future period the benefit of educational measures now begun, will be seen.

I will describe briefly the measures which it is proposed to adopt in Rangoon :— It is suggested that all milk be brought to a Central Receiving Depôt from the farms situated either within or without the municipal area, where the Health Officer will have opportunities of taking samples for bacteriological and chemical analysis, and that all dealers, who must be licensed, will have to furnish him with a list of the people from whom they obtain their milk. If on examination the milk proves to contain disease germs or to be adulterated, its sale may be prohibited. In the case of the former, the Veterinary Officer will have to thoroughly inspect the cattle and take such action as may be necessary.

It is estimated that 80% of the milk sold in Rangoon is produced outside municipal limits. At the present time Rangoon has not an Act of its own and works under the Burma Municipal Act. It is not clear at the present time whether this Act gives the Municipal Committee sufficient powers to deal with these outside sources of supply. In England I notice the officials of Corporations in towns have ample powers to visit and inspect the sanitary condition of the farms and the healthiness of the cattle, where the milk supply to the town is produced, and if these do not comply with the necessary requirements, the milk is prohibited from being sold within that town. It seems to me that the same procedure should be quite easy of adoption in this country.

Enquiries were made as to the conditions existing in Bombay, Calcutta, Madra and Karachi. The differences and circumstances of the milk supply in these town are sufficient to explain the variations in the proposals made for the control and th inspection of sources of milk supply outside the municipal limits in each case. I Bombay, it is said that the great bulk of the milk used is produced within the tow and that outside supplies form only a comparatively small proportion of the whole No measures are therefore considered necessary for such supplies. In Calcutta, it i estimated that one-third of the milk supply is imported and it is therefore considere necessary to take powers to deal with imported supplies. In towns where a larg percentage of milk supply is obtained from outside the limits of the town, it i obvious that any regulations which applied only to cows kept, and milk produced within the municipal limits would be utterly futile in attaining the object aimed at namely, the supply of pure milk to consumers.

The powers of inspecting sources of supply outside municipal limits should therefore be extended, and legislation will have to be obtained for this purpose. It is for this Conference to decide whether it should pass a resolution urging the Government of India to facilitate, and expedite as much as possible, the passing of the necessary Acts when application is made.

MILK TRADE.

BY

Dr. K. V. AMIN, L.R.C.P. & S. (Edin.) D.P.H. (Camb.)

Health Officer, Ahmedabad Municipality

The trade in milk may be divided into :—

(1) Production of clean milk.
(2) Carriage of clean milk.
(3) Storage of clean milk.
(4) Adulteration of milk.
(5) Staff for supervising the trade.

(1) The first thing for a municipality to do is to provide sanitary milch-cattle sheds situated well outside the city, and give them on low rental to cattle owners as a beginning. This would necessitate the cattle owners being turned out of the city under section 48(*c*) of the District Municipal Act. This will facilitate the inspection of milk and cattle, and also the conditions under which the milk is drawn and the cattle are stalled. The present bye-laws have the effect of making cattle owners shift from one place to another (as most of them have sheds on hire) within the overcrowded city.

A model dairy, say of five milch-cows, should be provided at municipal expense for educative purposes and to demonstrate ideals of cleanliness of sheds, of udders, hands of the milk-men, vessels, etc.

(2) Municipalities can make bye-laws under section 48(*d*) *ii* regarding the kind of vessels into which milk should be drawn, carried, and stored ; these vessels should be supplied at cost price to the milk-men.

(3) All cattle sheds owned or occupied by persons who trade in milk, all milk-shops, dairies, and milk hawkers, and ghee-shops should be licensed and registered, and the conditions of the license should be such as to insure thorough cleanliness with the least supervision. Government may be requested to grant these powers of licensing and registering cattle sheds, milk-shops and dairies, etc., to the municipality as none exist at present.

In the model milk-shop and model dairy kept for educative purposes at municipal expense, standard humanised milk for infants of various ages should be prepared and sold at cost price in one-feed bottles. This will tend to reduce a part of the infantile mortality which is due to faulty feeding of infants.

(4) Adulteration of milk and its products—

(*a*) Firstly, the minimum standards of the natural constituents of milk and ghee sold in this Presidency should be ascertained.

(b) The municipality should be empowered to make bye-laws prescribing the material, and size of sign boards, and size of letters to be painted on them. The name and address of the vendor should be fixed to each shop with description of milk sold, such as "separated milk," or metal plates should be fixed to milk vessels bearing a description of the milk, such as "separated milk" and the name and address of the vendor.

For want of powers to make such bye-laws there are a number of tricks played by vendors in order to evade the laws. Licensing and registration would enable the municipality to limit such practices.

(c) The procedure of sending samples for analysis to the chemical analyser with the Government may be dispensed with in cases where municipalities have Health officers qualified for the purpose, or have employed a special public analyst.

(d) Purchase of samples may be carried out by any person deputed by the officer empowered under section 142 of Bombay Act III of 1901 read with section 4 of Bombay Act II of 1899; the object of the purchase through the agent or detective may be notified by the said officer who should, of course, be in close proximity to the shop.

(e) Provisions analogous to section 142 of Bombay Act, III of 1901, should be inserted either in the District Police Act or Local Boards Act, with the power of extending the same to any important non-municipal town or village by a special Notification of Government.

The Health officer of the municipal district should be *ex-officio* public analyst of the municipality, as also of the nearest non-municipal town, and he should have the power of ordering destruction of unwholesome articles, whether perishable or otherwise.

(f) Shortage of milk leads to adulteration. Every effort should be made to increase the supply of milk by rewarding the good breeds of milch-cows and buffaloes and giving ample pasture lands either free or on easy terms for the benefit of milch-cattle owners.

(5) (a) There should be a separate veterinary graduate for inspection of all milch-cattle, their sheds, milk shops and dairies, with powers to seize such milk or milk products that are either not fit for human consumption or fraudulently adulterated.

(b) An assistant public municipal analyst to analyse all milk, butter, ghee, water, etc., should be appointed.

Unless there are ten or fifteen prosecutions instituted daily for adulteration of milk and ghee, and the magistrates inflict on the accused exemplary punishment, the trade in milk and ghee can never be purified.

Anything less than this would be only tinkering at the problem. The object can only be attained if there is a separate milk and ghee inspector and a separate municipal public analyst appointed for a big city like Ahmedabad.

A SHORT NOTE ON MILK SUPPLY.

BY

MAJOR T. S. N. STOKES, M.B., I.M.S.,

Sanitary Commissioner, Central Provinces.

THE problem to be considered was laid down in Colonel Wilkinson's paper at Bombay in 1911, *viz.*, how to obtain from indigenous agencies, *viz.*, the gwala, a reasonably pure and wholesome milk supply within the means of the ordinary inhabitants of Indian towns.

The subject is one beset with an extraordinary number of difficulties which must be familiar to all; it is unnecessary therefore to enter into their details or dwell upon the suggestions that have been made for circumventing them, as these can be found in the proceedings of previous Conferences. It may be of advantage, however, to describe briefly the measures adopted in the Central Provinces to meet the case, and I have therefore collected a few details from the Agricultural Department of this province which may be of interest to sanitarians.

Two dairies have been started in Nagpur—one, in connection with the Agricultural College is for educational purposes, the other, which is for the sale of milk, is worked on co-operative principles under the supervision of the same department. With the former we are not so much concerned as its object is instructional—its output of dairy products is extremely limited and is not likely to increase much.

The lines on which the second larger dairy has been started will, however, I think, repay consideration.

An area of 900 acres of grazing land situated around a large irrigation tank about two miles from Nagpur, has been acquired by Government in connection with breeding and seed farms, and a dairy farm has been started under the supervision of the Agricultural Department. It was found impossible to meet the demand for the milk, so a number of gwalas were induced to form a co-operative society which has since been registered as such. The terms offered to the gwalas were :—

(1) Good grazing and housing at 8 annas per mensem per milch animal, and 4 annas a head for dry or young stock.

(2) Concentrated food-stuffs (cotton cake, bhusa, etc.), at wholesale rates which are 25 per cent. below bazar prices.

(3) The services of Government bulls free of cost by which it is hoped to produce an improved strain of milch animal.

(4) The Co-operative Bank has agreed to finance co-operated gwalas to encourage the purchase of more animals.

The conditions on which gwalas' cattle are taken under the control of the dairy farm are :—

(1) All animals must be examined and passed by a Veterinary Assistant, and after admission they cannot leave the dairy or mix with other herds without permission. The gwalas managed to evade this rule and exchanged poor animals from outside for good milch-cattle, to the detriment of the scheme.

(2) Feeding, grazing, grooming and milking must be done by the gwalas and milk must be drawn in clean pails under the supervision of an overseer who sees that the operation is cleanly performed and the pails properly washed. The amount of supervision required is almost incredible—one man per five gwalas has his hands pretty full.

(3) Milk is handed over to the farm at 9 seers per rupee and is then made over at the same rate to a contractor who sells it at 6 seers per rupee. The margin of three seers per rupee being allowed to the contractor to cover the charges of supervision, distribution, etc.

(4) The gwala must carry out every measure of segregation, inoculation, etc., recommended on the outbreak of an epidemic in the vicinity.

The hot weather was a severe trial because many of the cattle ran dry, but the Co-operative Bank came to the rescue and financed the gwala society through the crisis.

The following statement, kindly furnished by Mr. Clouston, Deputy Director of Agriculture, shows the result of working the dairy from December 1912 to November 1913 inclusive (twelve months).

Average number of milch animals.	Average No. of dry animals.	Value of milk supplied @ 9 seers to dairy.	Value of foods bought.	Profits.
63	105	6,722-3-8	4,231-7-7	2,490-12-1

This result shows that 168 animals in all yielded a profit of Rs. 14-12 per head per annum by the sale of milk to the contractor at 9 seers per rupee. I do not know how the contractor's account stands, but believe that there should be a fair bonus for the gwalas when he has received 5-6 per cent. on his outlay. With regard to this matter of bonus, I believe it has not yet been decided whether it should be given or not.

The scheme thus outlined appears to offer a possible solution of the question; the countless difficulties in dealing with people of the gwala class can better be imagined than described; they have to be handled carefully and their grievances considered, while supervision must be absolutely unceasing in every detail.

Finally, it may be mentioned that at present the demand far exceeds the supply, and that it remains to be seen how far the scheme would expand if the rates were enhanced above the bazar prices.

SHORT NOTE ON MILK SUPPLIES.

BY

CAPTAIN H. G. STILES WEBB, D.P.H., I.M.S.

Deputy Sany. Commsr., North-West Frontier Province.

The many defects that are at present found are the following :—

Milk is collected in an insanitary way, conveyed to the customers in still more insanitary vessels, diluted with water containing the potential germs of many diseases, and lastly exposed for sale where infective dust and flies can further contaminate it, if such be possible.

These defects can only be obviated by registration and licensing of cow keepers and milk vendors and by the supply free, or otherwise, of suitable vessels, both for transit and for storage where the milk is to be exposed for sale.

Here we are up against a difficulty. If we have an All-India standard of purity, it must be one of sufficient latitude, so that whilst protecting the customer, it must not be too hard on the producer or vendor. It is found that cows' milk in this country varies considerably according to the season of the year and the nature of the food of the cow.

As nearly all the milk supply of large towns comes from the neighbouring villages, it follows that inspection of most of the milch-cattle would be a matter of some difficulty, likewise the inspection of their feeding and housing, very important points.

The only remedy that Ican suggest is the registration of the cows, and if possible, the testing for the presence of tuberculosis by tuberculin.

As to how these cattle are to be housed or fed is a matter for advice and not for compulsion ; the present exceedingly objectionable practice of keeping cattle in the dwelling houses is bad, both for man and beast.

The ideal thing would be for Municipalities to own and run their own dairy farms and shops.

A suitably run "sewage farm" can supply with ease the necessary fodder for a fairly large number of cattle, which could be daily brought to a central dairy and milked ; the milk being at once pasteurised or otherwise suitably dealt with. From thence it might be dispensed to licensed registered vendors, who would be under rigid inspection.

I will now give a brief summary of the conditions that obtain in the Government dairy farm, Peshawar.

This institution deals with the situation and conditions of milch-cattle that at present exist. in a way that is thorough and exceedingly creditable to all concerned.

This dairy farm houses a considerable number of Government-owned milch-cows and buffaloes, all of which have been tested and examined for the presence of tuberculosis; and in addition the neighbouring villagers bring their cattle to the dairy itself to be milked, the cattle being suitably housed and fed outside the cantonment. The milk is then immediately pasteurised.

The farm produces a very large proportion of the fodder required to feed these cattle; the land itself being manured by the excreta of the cattle kept at the dairy farm.

The whole is managed and run on up-to-date methods.

The need for such an institution is shown by the very large amount of infantile and other tuberculosis that is found in Peshawar and the Province in general. In this connection tuberculosis amongst the milch-cattle has not been found to be so rare as has been stated, and I am of opinion that this does play some small part in the dissemination of this disease in the North-West Frontier Province.

THE EXCLUSION OF STORM-WATER AND SILT FROM SEWERAGE SYSTEMS.

BY

MR. J. W. MADELEY, M.A., M.INST.C.E., M.Am SOC.C.E.,
Special Engineer, Corporation of Madras.

Paper is result of experience in Madras City.

1. The substance of this paper is the result of the writer's experience in Madras City. It is hoped that it may be of interest to those who are concerned with the drainage of the many mofussil towns of the plains where the conditions are similar to those of Madras.

An underground drainage system has already been installed throughout a considerable section of Madras and it is being extended to embrace the whole of the closely inhabited areas of the city.

When the first sections of the drainage system were put into operation they were found to be defective in many respects.

Among the principal faults were the free admission of silt and storm-water. By "*silt*" is meant heavy mineral matter, such as sand, gravel and road metal—mixed as it frequently is with leaves, straw, etc., which gets into the drains unless special means are taken to exclude it. In house connections and many open drain connections no attempt was made in the old system to exclude silt, while in the old pumping stations there was no provision to remove the silt and garbage brought in by the sewers.

Evils resulting from the free admission of silt to sewers.

2. It is found that silt in quantity chokes the traps that are fixed on every house drain. Mixed with leaves and sticks as it frequently is, the silt forms a matted mass that puts flat sewers right out of action, and the writer is convinced that if admitted in quantity this mixture would stop even the best graded sewers. Every time it rains, silt pours into the pumping station wells, cuts and wears away the interior of the pumps, and commonly when there is a storm, buries the suctions and stops the pumps just when they are most required. It is therefore absolutely necessary to exclude silt from entering sewers in any but small quantities.

Illustration of silting up of Madras sewers.

3. The diagram (Plate I) illustrates what occurs when silt is admitted freely into the Madras sewers. It shows the results of measurements on the "A B C Main", which is the principal intercepting sewer of the "Triplicane" Division of Madras, and which is constructed of 15-inch and 21-inch diameter pipes.

The surface of the silt was measured and has been plotted on the diagram. It will be seen that the pipe is more than half full in the higher reaches and rather less in the lower reaches.

This is an example of what occurs in the larger sewers. The smaller sewers have in many cases been completely stopped where silt is freely admitted.

Evils resulting from free admission of storm-water.

4. Storm-water also should be excluded as far as possible from a drainage system like that of Madras where all the sewage has to be pumped, and which is designed to deal only with the "dry weather flow, *plus* a small quantity of rain." If rain-water is freely admitted to such a system, the flow during the rains is multiplied many times, the sewers are unable to deal with it, the pumps are overpowered, the whole system becomes congested and sewage entering the pipes at the higher points of each area overflows at the lower points through manholes, and house connections, and often finds its way into the houses themselves. This is what now occurs in certain areas of Madras during heavy rain. At such times the sewers rapidly become surcharged, and the pumps would make almost as much impression on the ocean as they do on the water that is brought to them through the numerous openings which freely admit storm-water. In fact, the writer has seen one pumping station connected directly with the Bay of Bengal through the River Cooum, which was flowing to the pumping station as rapidly as the open drains would take it.

Special methods of excluding silt and storm-water necessary.

5. So bad are the effects of the admission of silt and storm-water in Madras that special measures have been found necessary, and special appliances have had to be devised. These naturally fall under the heads of :—

(*a*) House connections.
(*b*) Open drain connections.
(*c*) Pumping stations.

At the house and open drain connections specially designed apparatus is being installed to exclude silt and storm-water ; at the pumping stations apparatus to remove silt is provided. Some account of the special methods and appliances adopted is given in the following paragraphs.

House connections.

Classes of house drainage.

6. House drainage in Madras may be divided into three classes :—

(1) *First-class*, on the water carriage system, for those houses and buildings that are furnished with water-closets, baths, lavatories and sinks drained on European lines.

(2) *Second-class* drainage, retaining the existing open house drains. This system is used for the ordinary small houses of Madras, in which it would be most unwise to introduce underground drainage.

(3) *Third-class* drainage, for paracherries and collections of huts where each habitation cannot be provided with a separate sewer connection. These groups of dwellings are provided with sufficient latrines for the inhabitants, while a good class of open drain is constructed to remove sullage water from kitchens, etc.

With first-class house drainage, silt and storm-water in quantity are readily excluded by the usual well-known methods and no special reference is called for.

Separation of rain-water from sewage (Plate II).

7. The separation of rain-water from sewage in second class house drainage systems is effected by small brick or concrete curbs as shown in red on Plate II. These curbs divide the court-yards into washing places and rain-water areas. Rain falling on the roofs pours off the eaves, and, falling on to the court-yards, it is caused to flow at once into a "U" shaped storm-water drain, by which it is conveyed to the street side drain. The soiled water from washing places, and that from household utensils, is directed by the curbs into the sewage drain coloured yellow. A good deal of washing is done on the verandahs surrounding the court-yards. A small open channel is therefore constructed round the margin of each court-yard and is protected from rain-water by the usual curb. It will be seen from Plate II that this channel from the verandah empties into the sewage drain. By this means a practical working separation of rain-water from sewage will be effected.

In some cases, the rain-water and sewage drains are closed for short distances. For instance, the sewage drain is closed where it is found that rain-water will enter it, and the rain-water drain is closed wherever there is danger of sewage flowing into it. Governing these two principles is that of free access, and no drain or part of a drain should be allowed to be constructed that cannot be quickly examined and easily cleaned, when necessary. By throwing a bucket full of water down the sewage drain once or twice a day, it can be thoroughly cleaned out, and there should be no smell or unhealthiness, though it is an advantage to place a small flushing tank at the head of the open drain.

The method here described for the separation of rain-water from sullage has been carried out in the case of a number of houses and cost Rs. 50 on the average for existing houses. The extra expense in the case of new buildings would be insignificant.

In some cases it has been found advisable to supplement the use of curbs with eaves, gutters and down pipes, but in most cases curbs are sufficient.

Silt exclusion necessary at house connections.

8. The system of curbs for the separation of rain-water from sewage that have been described in the last paragraph, also serve to exclude a great deal of silt. It will, however, take a long time to make the necessary alterations throughout the whole city. Even when they are completed, it may be found that, from some houses, sand and ashes from pot scouring, etc., will pass down the drains in considerable quantities. Thus for many years to come, special means for excluding silt will be required at house connections of the second and third classes.

Type of "silt-catcher" used in Madras (Plate III).

9. To insure that no silt, or only a negligible quantity, shall enter from the house drains, a "silt-catcher" or silt trap has been designed. It is illustrated on Plate III. This is placed at the head of every second class house connection.

The silt-catcher consists of a steel bucket fixed in a masonry pit on the house drain. It is fitted with a diaphragm which passes across the bucket and extends 6 inches below the top of the bucket and 5 inches above. The sewage from the house drain flows over the rim of the bucket, strikes the diaphragm, and passes in a slow stream under it. It rises still more slowly for the area of the outlet side is greater than that of the inlet side. The silt settles and accumulates at the bottom of the bucket, while the liquid flows over the rim on its way to the syphon trap. If left to itself, the silt will gradually fill the bucket up to the bottom of the diaphragm. It should be emptied regularly before it reaches this level, but if neglected, the silt

will accumulate on the inlet side, mainly, until the inlet side is deeply silted up. Filtration of the liquid through the silt then becomes slow, and the incoming sewage backs up against the upper part of the diaphragm until it overflows through the tell-tale hole into the road drain or ditch, and indicates clearly to every one that the bucket is in urgent need of attention.

There are two alternative methods of fixing the silt-catcher. In one, where the fall to the sewer is only just sufficient, a separate chamber is provided as shown in Plate III. In the other, where there is ample fall, the silt-catcher is placed over the syphon trap and the sewage flows over a notch in the bucket, down a groove in the masonry pit to the trap. While both methods of fixing have proved satisfactory, the latter is preferable where the conditions permit, because the cost is slightly less, and the silt cannot get under the bucket so as to prevent it sitting properly.

These silt-catcher buckets have been in use in Madras now for some three years, and have proved entirely satisfactory. The accumulation of silt in the siphon traps and sewers in the streets where they have been fixed has been very much reduced and the sewer and drain cleaning departments of the Corporation have been agitating for some time to have silt-catchers installed over the whole of the city. A scheme is now on foot to do this in conjunction with a complete reform of drain cleaning arrangements. From the result of the working of these silt-catchers, it is found that they require cleaning on the average once in four or five days. The cost of the bucket itself is Rs. 1½. From experiments on three streets provided with seventy-seven buckets, it was found that the silt-catcher removed 90 per cent. of the silt, but very little sludge.

THIRD CLASS CONNECTIONS.

Drainage of Paracherries, etc.

10. For a long time to come, there will exist in Madras, paracherries and collections of huts where each dwelling cannot be provided with a separate connection to a sewer. In such cases, the most practical method of drainage is to provide a sufficient number of suitable latrines for the use of the inhabitants of paracherries, and to furnish the houses with a good class of open drain for the removal of sullage water from kitchens, etc. These open drains are protected by constructing low curbs on the roadside a little higher than the road level. This prevents stones and sand being washed into them, and obviates a great deal of the labour which would otherwise have to be expended in clearing road metal out of drains after heavy rains.

Exclusion of silt and storm-water from open drain connections.

11. It is of vital importance that the connections of these open drains to sewers should be furnished with means to exclude silt and storm-water, and apparatus of different descriptions have been designed for Madras. They consist of silt pits to catch heavy materials, each combined with a rain-water separator of one of the following four types :—

(1) Ordinary Overflow Weirs.
(2) Leaping Weirs.
(3) Plate Weirs.
(4) The Madras Storm-water Separator.

In the case of the ordinary *Overflow Weir*, the inlet to the sewer is constructed so that when the flow exceeds the maximum allowable, the excess water passes over a weir provided for the purpose, and flows away to the storm-water drain.

In the *Leaping Weir* method of separation, the liquid normally drops down an

opening in the drain into a pipe leading to the sewer. In times of rain when the flow becomes excessive, the rush is sufficient to carry the liquid right across the opening into the rain-water channel.

The *Plate Weir* is an alternative to the ordinary weir. In this case, a plate is placed horizontally across the channel at such a level, that the dry weather flow passes freely underneath it, but in times of rain the level of the liquid is raised until it reaches the plate, when a portion of it passes over the top of the plate and is diverted into the rain-water drain.

The Plate weir has this advantage over an ordinary weir that, whereas in the latter case, the flow increases continually even after the overflow comes into operation, in the former the quantity of liquid which flows to the sewer diminishes slightly as soon as overflow begins. The reason for this reduction in flow is, that when the liquid surface touches the plate, the friction between the water and the plate reduces the rate of flow. The action is analogous to that of an ordinary pipe which discharges more when nine-tenths full than when flowing just full.

In any particular case, the most suitable of these three types of storm-water separators is used where necessary and possible. Where there is an underground system of storm-water sewers no other method is required.

Madras storm-water separator (Plate IV).

12 Owing to the absence of rain-water drains however, there is flooding in hundreds of the streets of Madras during heavy rainfalls, such as would completely submerge any separator of the types described above.

In fact the ordinary weir and the leaping weir types would form openings down which immense quantities of silty water would rush into the sewers. The Madras type of separator has been designed to work when totally submerged.

Plate IV shows the separator applied to the connection of a side drain to a sewer. The drain discharges into a silt-pit through whch the sullage passes on its way to the separator chamber, which is provided with a suitable cover or grid. In the most convenient side of the separator chamber is formed the outlet connecting with the pipe which leads to the sewer. This pipe is provided with an intercepting trap and, if required, may be fitted with a ventilator and an inspection shaft. A grating is fixed at the inlet end of the silt-pit, and a second grating is provided to protect the regulator. An overflow weir is formed on one or both sides of the drain close to the point where it enters the silt-pit. In times of heavy rain when the outlet has been closed or partially closed as described below, the storm-water is discharged over this weir into an overflow channel.

The storm-water separator consists of a ball valve which may be made of wood, copper or other material and is weighted so that it shall be submerged to the required depth. The ball is made of such a size and shape that when in register with the outlet, it wholly or partially closes the same, according to the amount of liquid that is to be allowed to enter the sewer. The floor and walls of the chamber between the silt-pit and the outlet are shaped to serve as a path or guide for the ball valve, as it is carried along by the liquid flowing through the chamber. The ball constitutes the means of controlling or regulating the flow through the outlet. The liquid in passing towards the outlet causes the ball to remain in engagement with the curved path formed in the floor of the separator chamber. Starting with the silt-pit emptied and the ball valve at the lowest point of its path, then as the surface of the liquid rises, the ball also rises and partly throttles the outlet, permitting only a definite quantity of liquid to pass through it. When the liquid reaches a pre-determined level, the ball valve closes the outlet as completely as is

allowed. By varying the contour or profile of the ball path, or by varying the size and shape of the ball valve or orifice, or by altering the weight of the ball valve, the flow may be regulated as desired. To assist in retaining the ball valve in its path, should a sudden or heavy rush occur, and as a protection against wilful tampering, a guide or cage is provided. This cage is also employed to limit the rise of the ball in order that the outlet may not be completely closed by the valve. A number of these storm-water separators are now in operation in Madras. It is found that they give very satisfactory service provided the silt-pits and gratings are regularly and properly cleaned.

Elimination of silt and rubbish (Plate IV).

13. Every type of storm-water separator at the junction of a side drain with a sewer must be provided with some method of extracting rags, sticks, leaves, and other refuse and also the means of eliminating the silt. This is conveniently done by means of a suitable grating to exclude the coarse floating matter, and a silt-pit to allow of the deposition of heavy grit, stones and silt, which are continually carried into the side drains, especially when it rains. A suitable arrangement of grating and silt-pit is shown on Plate IV where there is illustrated a curved grating of a type especially designed to deal with Madras refuse. The grating is of such a form that a considerable quantity of refuse may collect on it without interfering with the flow of sewage and of the silt it carries in suspension. After passing through the grating, the sewage enters the silt-pit, so formed that it constitutes a receptacle for silt and the like below the flow level. A diaphragm or baffle plate, which in Madras takes the form of a Cuddapah slab, is built into the walls of the chamber, and causes the entering liquid to flow in a downward direction, and thus materially assists the settling of silt. The silt-pits are provided with heavy doors and yet are readily accessible for cleaning. Square corners are avoided and the bottoms are rounded in such a manner that the silt will fall readily towards the cleaning scoop. Small platforms with curbs and draining gaps are provided on to which to draw the sticks and large refuse collected by the grating.

Pumping Stations.

Evil effects of silt at pumping stations.

14. Until the above described methods of excluding silt and garbage are completed, a large quantity of grit road, metal, leaves, sticks, and other material will be carried through the sewers to the pumping stations. The quantity of silt and garbage that reaches a Madras pumping station is very large.

In consequence of the complete absence at the old pumping stations of any arrangements for removing silt, and for freeing the sewage of floating materials such as leaves, cocoanuts and the like, there is a constant and rapid accumulation of deposit in the suction wells. This eventually closes up the suctions and makes it necessary to employ continually a gang of divers, who, in order to remove the silt, have to work submerged in sewage, an exceedingly filthy, and indeed a dangerous operation. A considerable quantity of silt and floating material is not deposited in the pump wells but is drawn into the pumps. The silt serves to grind away the surfaces of the pump rods and plungers, while the leaves and other floating material choke the pumps and prevent their efficient working.

Evil effects of silt in pumping mains (Plate V).

15. The importance of screening sewage in removing all the silt when it has to be forced through pumping mains is fairly obvious. When it is remembered that in sewers running downhill, where gravity assists the flow, a velocity of $1\frac{1}{2}$ feet per second is

required to move along even small quantities of silt, it appears obvious that, in order to move silt uphill against the force of gravity, a considerable greater velocity will be required. It is therefore to be expected that there will be a deposit of silt in all the low places in a long pumping main conveying sewage with silt in suspension, unless the velocity is high. This has been proved to be the case in the Madras pumping main, which is shown in section on Plate V. When the main was cut at a point some two miles from the discharge end, it was found that the pipe was full of silt up to two-thirds of its height. The silt consisted of a mixture of stones, sand and bricks, all matted together into a felt-like mass by leaves, sticks, etc. As a consequence, the writer thought it well to experiment with the existing cast-iron main throughout its entire length of eight miles to ascertain to what extent its carrying capacity had been reduced. The result has been to prove that the effective area of the main, averages about one-half of its actual area, as shown on Plate V.

Arrangement of silt-pits and screening chambers (Plate VI).

16. To obviate the evil effects of admitting silt and floating materials freely to the pumping stations and pumping mains, special arrangements have been made and special appliances designed. The general arrangement of silt-pits and screening chambers used for this purpose is shown on Plate VI. The incoming sewage first enters the circular collecting well, whence it can be turned so as to pass through one or both of a pair of combined silt-pits and screening chambers. These are circular brick wells with the bottoms formed as inverted cones. The inlet and outlet pipes—both provided with valves are connected with these chambers at the top of the cone. The sewage entering by the inlet pipes loses its velocity in the large area presented by the pit, and the silt and other heavy materials in suspension drop to the bottom, and are from time to time removed by a "silt-raiser" of a design which is illustrated on Plate VI. It consists of a fixed Tee pipe suspended over the centre of the silt-pit. Inside this slides a moveable pipe, the bottom end of which can be dropped on to the top of the silt, while the top end remains within the Tee pipe at a point below the branch. The branch leaves the silt-pit some two or three feet below the top, and leads to a settling basin at or about ground level. The operation of raising the silt deposited in the cone shaped depression of the silt-pit is as follows :—

The valves on the inlet and outlet pipes are closed. The chamber is filled with sewage from the pump discharge—though when clean water is readily available it is better—and the valve on the Tee pipe branch is opened. There is then a head of some 2 feet 6 inches tending to drive the liquid in the silt-pit up the moveable pipe and out through the Tee branch to the settling tank. The bottom of the moveable pipe is kept close to the surface of the silt, and the liquid in rushing up the pipe, scours away the silt and carries it up and out along the branch to a small settling basin, where the clear liquid is syphoned off and the deposited silt is subsequently shovelled into carts.

Plate VI shows a typical silt-pit and screening chamber, with a silt-raiser at its lowest position as in use at two sewage pumping stations in Madras, and which is being installed at all the pumping stations. The silt-raiser is operated every morning as a matter of routine, and the silt is removed before any great quantity accumulates. The cleanliness of this method of removing the silt is very marked as compared with the filthy method employed at the old stations where divers are used. These men have frequently to submerge themselves in sewage and scrape

PLATE III.

FIG. 1.

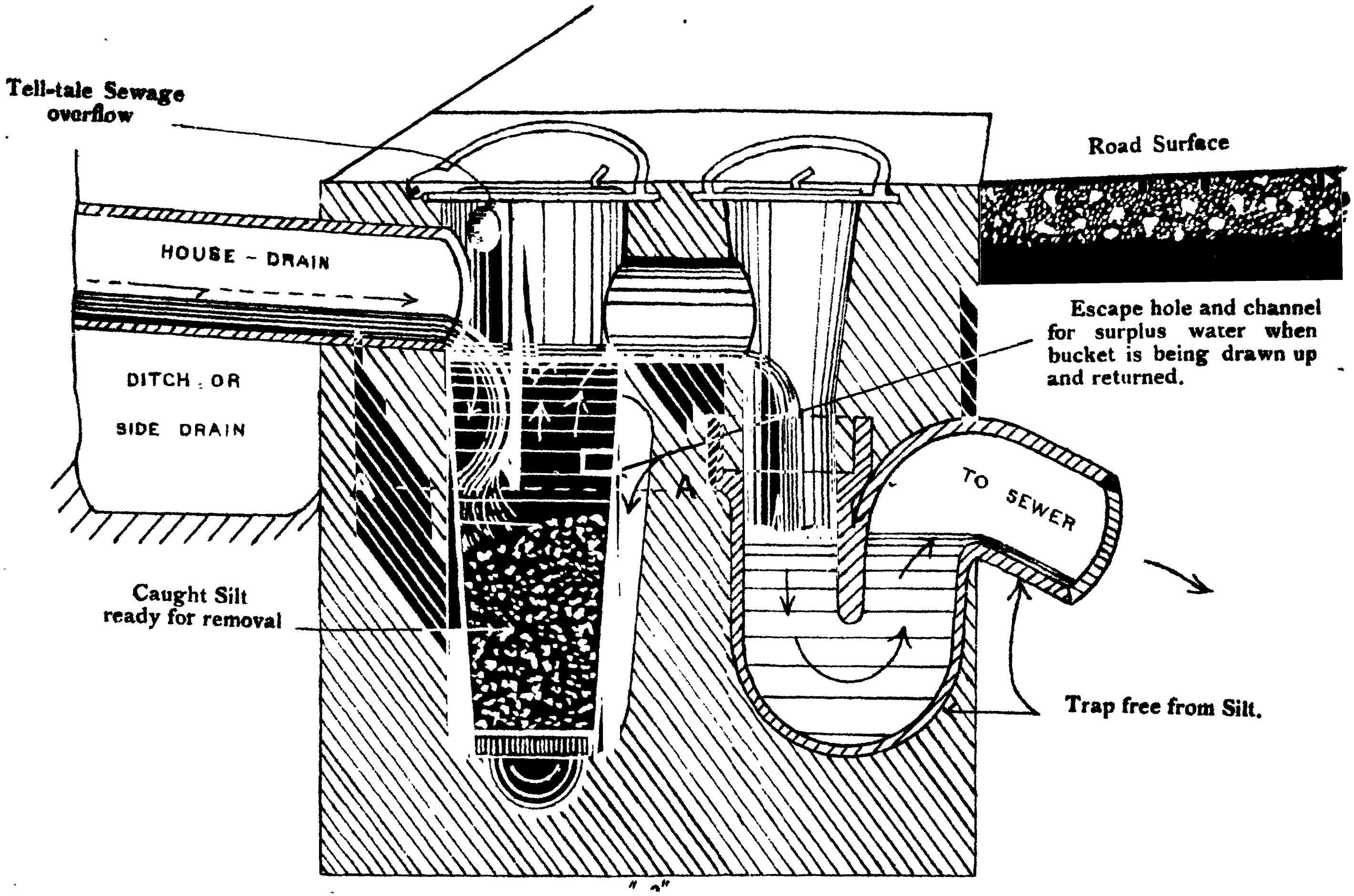
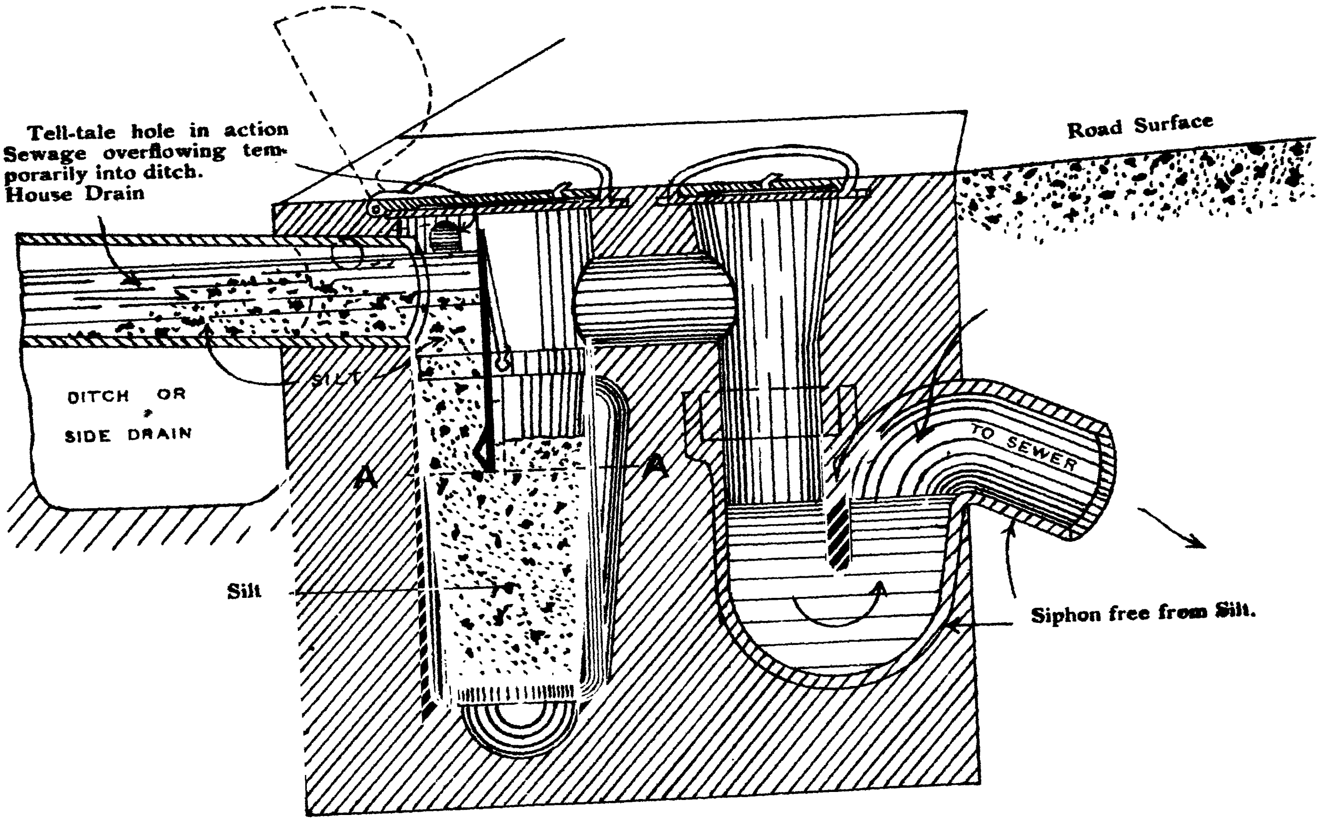


PLATE III.

FIG. 2.

The Silt-Catcher, neglected, has closed automatically all exit to the Sewer.



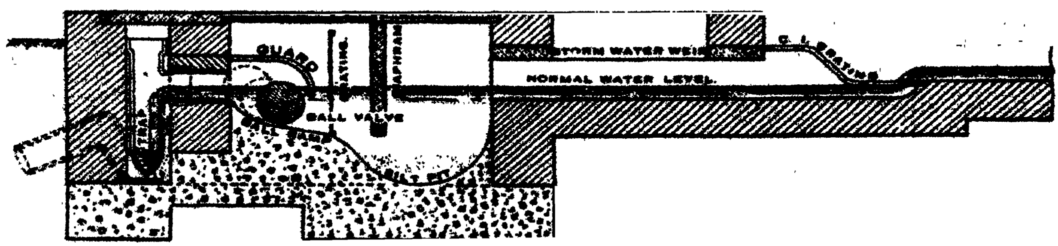
NOTE :—The Silt-Catcher bucket should be emptied before the Silt gets up to level A A, which is the bottom of the diaphragm. If neglected, the Silt fills up mainly on the inlet side, as shewn, and at last causes stoppage at bottom end of house drain, but the Sewage will run out through the tell-tale hole and give warning before complete stoppage takes place. No Silt can get past the Catcher into either Siphon or Sewer.

PLATE Nº IV

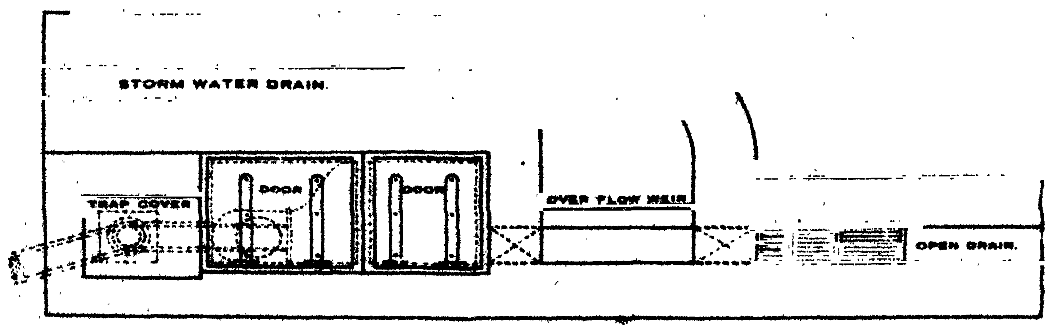
"MADRAS" PATENT STORM WATER SEPARATOR

SHOWING APPLICATION TO CONNECTION OF SIDE DRAIN TO SEWER

SECTION



PLAN



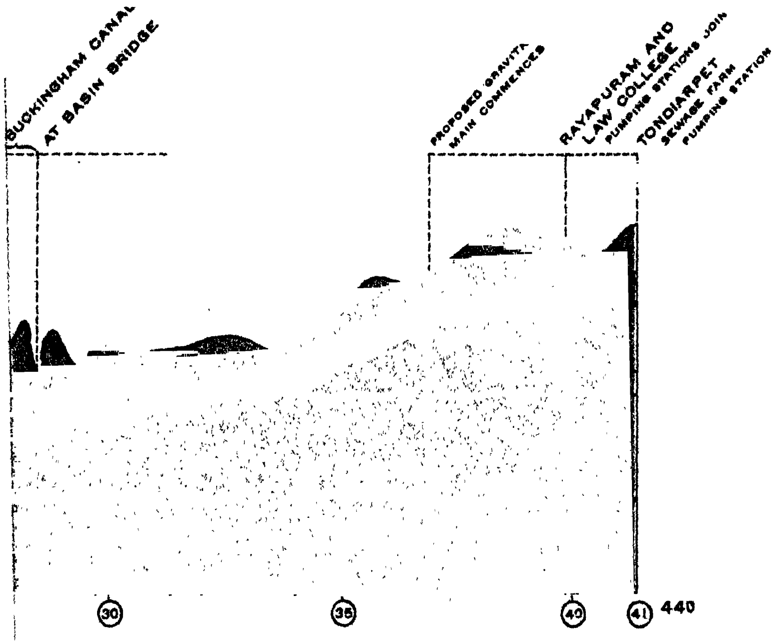
J. W. Madeley M.A.

INST. C.E., M. AM. SOC. C.E., ETC.,
SPECIAL ENGINEER,
CORPORATION OF MADRAS.

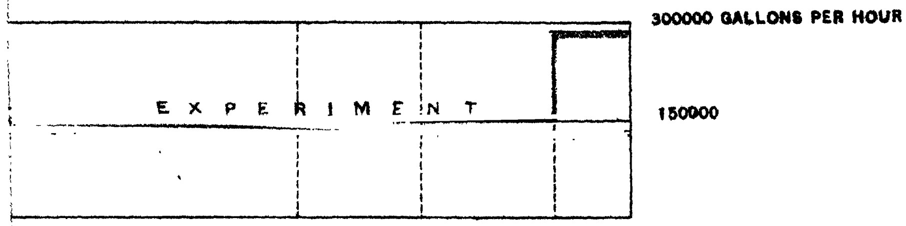
Plate V.

MAIN.

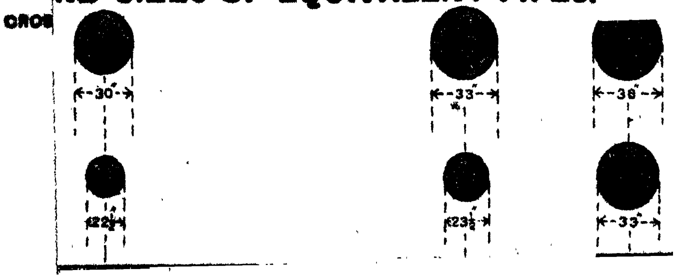
IENTS, ETC.



NT ON 19TH OCT. 1912.



ND SIZES OF EQUIVALENT PIPES.



away the mixture of silt and leaves which rapidly collects close to the pump suctions.

Screens (Plate VI).

17. To remove floating material, screens are fixed on the outlet side of the silt-pits. They consist of light moveable cages made of steel rods, well painted to preserve them from corrosion. When a cage is sufficiently charged with refuse it is raised above the top of the chamber by means of a light hand crane and swung over a cart. The flap door forming the bottom to the cage is then opened by releasing a catch, and its contents dropped into the cart which conveys the refuse to a destructor. The interior of the cage is then scraped down lightly with a rake, the door slammed up, and the emptied cage let down again to its original position in the sewage flow.

A SHORT NOTE ON SEWERS.

BY

MR. J. BALL HILL, ASSOC M INST.C E.,

Executive Engineer, Corporation of Calcutta.

1. The important work of sanitation in India, including the detection and control of adulterated food supplies, treatment of epidemic diseases, control of over-crowding, water supply, disposal of refuse and sewage and other matters pertaining to the health of communities, presents to the authorities concerned, especially to Health Officers and Sanitary Engineers, most interesting problems for solution.

2. The following note, however, will chiefly refer to the particular branch of sanitation which has to deal with the disposal of sewage, including night-soil, *by underground sewers.*

3. The difficulties in this branch of sanitation in India is not so much the determination of what system "*would-be*" the most suitable from a sanitary point of view solely, as in the determination of the method by which the sanitation of the villages and towns of India can be dealt with economically, bearing in mind the comparative poverty and prejudices of the masses of the people, and the ability of the particular community concerned to meet the cost and maintenance of it.

4. There can be no doubt, in my opinion, that in thickly populated compact villages or towns, where the community can afford the cost and maintenance, the water carriage system of sewage disposal by underground sewers to a septic tank, or farm, would be found the most healthful. There are, however, homesteads, or small villages, of a few to a score or so of population, scattered over the vast plains of India, where it would be perhaps difficult to introduce such a system of sewage disposal, or even middens, or the dry earth, or the pail systems of Europe. In such places, the people are in the habit of squatting on adjacent land, and leaving matters for the earth and sun to dispose of. This primitive custom becomes a nuisance, from a lesser to a greater degree, depending on the size of the village.

5. Some of these villages grow, until it is absolutely necessary to require the introduction of mether service, and a trenching-ground, together with surface drains to dispose of foul drainage.

6. Up to a certain condition of affairs, it will, probably, be considered that a trenching-ground for night-soil, and the disposal of urine and sullage water over the soil, or into kutcha earth surface drains, as long as the earth is not over-saturated and retains the power of absorption and nitrification without giving offence, may be accepted as measures which are not easy to be improved upon in India with its powerful sun, especially as both the trenching-ground and sullage form valuable assets as manures to the cultivators

7. Up to this point such villages may not require much attention from an expert Sanitary Engineer, for the village headmen with but rudimentary education in sanitation could be taught to select the best position for trenching-grounds and to see that no washing from it or other foul surface drainage could flow to the sources of water supply of the village either during the dry weather or monsoon seasons.

8. With the gradual increase of the population and the over-saturation of the soil of the surface drains and the destruction of the nitrifying powers of their earths, will come the necessity for the advice of the Sanitary Engineer who will have to determine the most economically satisfactory project to dispose of the drainage. The problem may resolve itself into a simple method of the continuance of the trenching-ground and the disposal of the sullage water by pucca masonry surface drains to a suitable outfall.

9. A state of affairs may, however, be reached when the disposal of the night-soil by trenching and the use of surface drains for carrying off drainage will become an intolerable nuisance, and a system of underground sewers will form the only satisfactory means of disposal both of sullage water and night-soil.

10. Whatever expenditure has been incurred on surface drains will not necessarily have been wasted, for by the insertion of gullies at reasonable intervals any drainage whilst fresh can easily be diverted from them to the sewers.

11. It is to the system of disposal by sewers that I particularly wish to refer in this paper—*viz.*, the determination of the most economical sizes and gradients, and junctions of sewers for drainage systems.

12. Judging from conditions existing in the old Calcutta town sewers designed so long ago as 1856, it is evident that this was no easy problem. Calcutta is well drained, notwithstanding the defects in the town system and very great credit is due to the Engineer who was responsible for the work, but there are defects in the suburban area sewers, constructed so late as 1896 to 1900 which are hardly excusable.

13. Generally the main sewers of the town area of Calcutta are egg-shaped in section and were designed to discharge on the combined system an amount equivalent to $\frac{1}{4}$ inch of rainfall per hour or 15 c. ft. per minute per acre; the maximum average sewage flow is about 1·6 c. ft. per minute per acre, and average population 144 per acre.

14. The suburban sewers are circular in form and discharge 3·5 to 2·7 c. ft. per minute per acre, 0·5 to 0·9 c. ft. being the maximum average sewage flow. They are assisted in the relief of storm water by surface drains and together provide for a discharge of about $\frac{1}{6}$th of an inch of rainfall per hour.

15. Both the town and suburban sewage is pumped and discharged in its crude state into the Biddyadhuri, a tidal river some 5 miles east of the city.

16. The storm water is discharged into the storm water reservoirs direct. The reservoirs, designed to store the discharge of storm water during the period the tides rise above the free flow level of the sewers and surface drains, discharge their contents into the Biddyadhuri river on the ebb tide through 11 Stoney's roller gates, each, of some 18 × 14 ft. waterway.

17. The following are defects which exist in some portions of the Calcutta system of sewers which I think it wise to bring to notice in order that in future such defects may be studiously avoided.

18. One large and important main intercepting sewer, where it is increased in size at various points along its length to admit the discharge of branches, has the

larger down stream sections stepped up from the soffit instead of being stepped down at the invert, the line of the invert of the sewer being practically unbroken. It cannot consequently receive the additional discharges of the branches without heading up and retarding the flow coming down from the up-stream sections.

19. A large number of the town branch sewers join the main sewers practically invert to invert. They should have joined soffit to soffit, or with their inverts sufficiently above that of the main sewer as would enable their discharge "under free flow" to either fall down on to, or join at, the same surface level, the sewage running in the main sewer. The result is that considerable silt accumulates along these branch sewers which has to be removed by hand; the velocity of the sewage having to flow through an increased and unnatural area, is not sufficient to flush the silt along into the main sewer and thence to the outfall.

20. Although the sewers themselves are well graded certain main sewers are not of sufficient capacity to take the flow of their branch sewers. For instance in the Suburban Area a 30″ diameter main sewer having a capacity of only 1,009 c. ft. m., was laid to take the discharge of five 21″ and one 15″ diameter sewers of a joint capacity (unobstructed) of 4,054 c. ft. m., without any means of overflow for the excess discharge at their junction with this main.

21. As summits, there are several 24″ diameter sewers of from 2,000 to 5,000 feet long laid with the same gradient throughout their length, instead of having been decreased in size and capacity from the main towards their summits in proportion to the drainage area they have to deal with.

22. These defects demand constant and recurring expense in keeping the sewers free from silt, and the use of immense volumes of, otherwise unnecessary, flush water which has to be dealt with at the outfall pumping stations.

23. There is no remedy for the continuance of this state of affairs in these sewers except heavy expenditure in their reconstruction.

24. It would appear as if these 24″ branch sewers must have been determined on the erroneous bases that a certain gradient was found to be available between the summit of the area to be drained and the main sewer, and that on reference to discharge tables it was found that the sewer for that gradient, necessary to give the required self-cleansing velocity running full or half full, would have to be 24″ in diameter, so these were put in; but the important factor as to whether these sewers could possibly obtain from the areas they drain, the necessary quantity of drainage to run them full, or half full, or discharge the sewage flow alone with a self-cleansing velocity, evidently, must have been overlooked.

25. Those who have been specially trained in the design of drainage systems, will know how to avoid such errors, but comparatively few in India, probably, have as yet acquired the necessary experience, from want of opportunity, and for such who have this work to prepare, it will be of assistance to have pointed out that in the preparation of either large or small drainage projects, it is essential to determine the following data :—

(*a*) The present and possible future population of the area to be drained.

(*b*) The best alignment by careful determination for the main and branch sewers.

(*c*) The total area to be drained by the main sewer from summit to outfall. This should be sub-divided into the areas drained to it by each of the branch sewers and these branch sewer areas again sub-divided.

(*d*) The quantity of sewage at the probable daily maximum average rate which may be expected to be received into the sewers during the period of

greatest dry weather flow, say over about 6 to 8 hours of the day. This may be estimated from the population and rate of water-supply, and is generally found to be at the rate of half the total daily flow in six hours.

(*e*) The maximum quantity of rainfall per given period in addition to the maximum quantity of sewage, say in cubic feet per minute per acre, that it is desirable that the sewers should take away.

(*f*) For the particular standard shaped sewer, which it is desired to adopt, circular, egg-shaped, or other regular form, the ratio between the velocity required for the maximum average dry weather flow of sewage, (which should not be less than 2 ft. per second) and the velocity required for the sewer section when flowing full with the combined sewage and rainfall. Having arrived at this :—

(*g*) Then by the sub-divisional areas and the quantity of sewage and rainfall, per acre, or bigha, or other unit adopted, both the sizes and gradients of the branch and main sewers, throughout their length, can be proportionately settled upon by selecting sewers of such diameter or size, and gradient, as will carry flowing full, from their drainage areas, the combined maximum quantities of sewage and rainfall in cubic feet per minute at, as nearly as possible, the required full flow velocity, say in feet per minute.

(*h*) As long as the full flow velocity of the sewers selected under these conditions is not less than that required by the standard section, it may be safely assumed, without further calculating, that in any of the sewers, the required velocity of 2 ft. per second with the maximum average sewage flow will obtain.

(*i*) Provided the sub-divisional areas and selection of sewers are carefully made, the addition of the falls due to the gradients of main and branches, from outfall to summit, and the differences required for the proper adjustment of the inverts at changes of sewer sections, will show the minimum depth that the outfall will have to be below any summit area, in order to properly drain it, and also whether it is possible to drain the area to any particular point without pumping.

(*j*) By the systematic working out of a project for sewers or surface drains on the above principles, it will be possible to arrive at a properly sectioned scheme, with the minimum of loss in gradients, and of expense. Especially is this important in flat districts having treacherous subsoils.

(*k*) Adequate means for automatic flushing should be made at the head of branch sewers, especially so in cases where the connection of premises is likely to extend over a number of years ; the mains may then be left to look after themselves.

26. There are of course cases, for instance, where the flood water to be provided for in proportion to the sewage flow is abnormal, in which sewers of special and irregular section are required. I have recently built one such at Calcutta whose flood discharge of 10,000 c. ft. m. is about 15 times the maximum average sewage flow, the vertical diameter available being only 8 feet and gradient 1 in 3,500.

A brief paper of this description can, however, only indicate general principles in the design of regular shaped sewers.

THE DISPOSAL OF SEWAGE SLUDGE.

BY

MR. D. W. AIKMAN, C.I.E.,

Superintending Engineer, 2nd Circle, Punjab.

IN India, the few large towns which have adopted the modern method of sewage removal by water carriage have, so far, found it unnecessary to go in for artificial sewage purification as they have been able to depend on natural purification by dilution, discharging the crude sewage into the sea or large rivers. Although there has yet been no necessity to tackle the question of sludge disposal on any large scale in India, yet, I can foresee for the reasons given in the next paragraph that it is likely to be one that all Sanitary Engineers and Health Officers will have to deal with in the near future.

In most Indian towns the night-soil is removed and trenched by sweepers. With the spread of primary education I have noticed a very distinct and growing tendency for the sweeper to forsake his hereditary calling and earn his living in any other way. As he becomes scarcer he becomes dearer, and will thus force the large municipalities to adopt water carriage removal of their sewage on grounds of economy alone, neglecting the possibility of the scarcer and consequently overworked sweepers going on strike. A sweeper strike lasting even for a week in a large municipality dependent on hand removal of its night-soil would render the town pestilential.

If my surmise be correct, then, in the comparatively near future many of the larger Indian municipalities will have to adopt water carriage for the removal of sewage. A considerable proportion of these towns will have no sea or large enough river into which the crude sewage can be discharged for natural purification. These towns must therefore adopt artificial purification and consequently must face the difficult sanitary engineering problem of the disposal of sludge on a large scale. Before giving a more detailed description of the latest method of sludge disposal, I will give a brief account of the various attempts made to solve this difficult problem. When the Rivers Pollution Act came into force, and prevented crude sewage being discharged into the rivers and streams in Britain, sewage was turned on to land for purification but this soon proved a failure. At first this was thought to be due entirely to the clogging of the soil by the sludge, so the separation of the sludge from the liquid sewage by sedimentation or chemical precipitation was therefore resorted to, and then the question of disposal of the sludge arose. Sludge was found to have practically no manurial value. As crude sludge contains over 90% of liquid, before

it can be carted away it must be dried. Many towns in England put up expensive sludge presses, to make the sludge into cakes, that could be handled, but this process is expensive, dirty and odorous. Other towns run or pump the sludge into lagoons, where it is reduced in bulk by slow septic action (with smell) and evaporation and often it is further treated on drying beds.

At one time it was thought the sludge problem would be settled by passing the crude sewage through septic tanks, where the greater part of the organic matter in the sludge is used as nutriment for the anærobic microbes. This procees has so many disadvantages that it is now abandoned, the chief one being that the liquid flowing from the septic tanks was in a state of putrifaction, it was difficult to purify, and when purified, was liable to secondary putrifaction.

A very ingenious form of tank, invented in Germany, is one in which the solids are deposited into a partially separated chamber at the bottom where septic action is allowed to take place and thus reduced the volume of the sludge, while the liquid portion of the sewage is passed rapidly through the tank to prevent putrifaction and is purified by further treatment without difficulty.

All these processes, at best, only reduce the bulk and weight of the sludge which has still to be disposed of. Its manurial value is so small, that it does not pay the farmer to cart it away.

One of the best solutions of the sludge problem which is very suitable for small towns up to 10 or 15 thousand population, especially where good slate is available at a reasonable rate, is Debdin Slate Beds. As these have been in constant use in England for the last 8 years, their method of working is familiar to most of us, so I will confine myself to a very brief description. The slate beds are usually from 3½ to 4 feet deep and the floor slopes to the outlet. The slates are laid loose, with their edges close together, in cubical blocks of slate (about 1½″ to 2″ cubes) layer above layer to the top. The crude sewage, after passing the detritus tanks, is run into the slate bed till full, the bed is then left full for about two hours, during this time the sludge settles on each layer of slates in thin layers, the outlet valve is then opened and the bed emptied, it is allowed to remain empty, with the outlet valve open, for about six hours for aëration, then the cycle of operations is repeated. The thin layers of sludge deposited on the slate layers become a culture medium for aërobic microbes which are assisted in converting the organic matter in the sludge into an inorganic residue by ground worms and other forms of life, which break up the solids in the sludge. When the bed is ripe, each time the outlet valve is opened and the bed discharged, a considerable portion of spongy earth comes away with the liquid, this Dr. Debdin has named *humus*. On account of the frequent aërations no septic action takes place, the sludge is digested almost entirely by *aërobic* microbes, consequently the *humus* has no bad smell and it is much freer from liquid than sludge. It is easily separated from the liquid sewage, and is then put on drying beds, and when dry becomes a valuable manure. A good idea of the extent of reduction in the sludge by this *aërobic* treatment is given by the following results obtained at Devizes (7,000 inhabitants), which was the first town to adopt this system. Prior to its introduction chemical precipitation and sludge presses were used and 700 tons of sludge cake of no manurial value had to be disposed of annually; now, there are only some 50 to 60 tons of dry *humus* annually, and this has a ready sale as manure. Unfortunately, however, this process is only suitable to comparatively small towns as the beds being only 4 feet deep or less, and they cannot be made deeper as the time it would take to fill and empty deeper beds would not allow sufficient or frequent enough aëration and further, much of their

capacity is occupied by the slates and the layers of sludge on the slates, they would consequently take a very large area and land round large towns is generally much more valuable than that in the vicinity of smaller towns.

For large towns, the sludge disposal plant started at Oldham (nearly 1,50,000 inhabitants) on the 26th October 1912 promises to be the solution. I have known for the last 2 or 3 years that experiments were being carried out for the Oldham Corporation as to the best means of sludge disposal, and when I saw a short notice in one of the Engineering papers that the Oldham plant had been started, I wrote to the inventor of the plant Dr. Grossmann, Chemical Engineer, Manchester, asking if he would kindly supply me with details. This he most courteously did in a very complete manner.

In order that no point may be omitted, I think it best to quote his letter almost in full, as follows :—

" In Oldham, ordinary sedimentation is used for the removal of the sludge. The latter may thus be worked up into manure almost as quickly as it settles out, and, therefore, has no time to decompose and become offensive. It is one of the features of my process that there are no accumulations of sludge, and this is one of the reasons which makes it so satisfactory from a hygienic point of view. Since the formal opening of the plant I may say, that the machinery has been working continuously, night and day, without stoppage or break with most satisfactory results."

" It may assist you in forming a just opinion of my process if I briefly explain the principle upon which it is based. It has been assumed for a considerable time that considering the amount of nitrogen, potash, and phosphates which are present in sewage sludge, and which are the principal ingredients on which plants thrive, the sludge should be an excellent manure, but wherever tried, it has been proved to be almost worthless on the land, and special experiments, which were carried out by the most eminent Agriculturists in this country under the direction of the Royal Commission on the Treating and Disposing of Sewage, have conclusively shown that sludge is almost useless as manure. I have for the last 15 years been chiefly engaged in the study of this question, and came, in the first place, to the conclusion that the low manurial value of sludge was due to its containing fatty matter, which surrounded the active ingredients and prevented them from nourishing the plants, and also clogged up the soil and rendered it impervious to air and water. It therefore became a question of removing the fat, which is chiefly due to the soap which is used in every household and ultimately finds its way into the sewers, and I specially directed my attention to determining which would be the best way to eliminate the fatty matter. I first tried to do so by extraction with solvents, such as benzol, and then by gasification, and found that these methods were economically unsound and impracticable, and without entering into further details on these purely technical and commercial matters, I may say that I can conclusively prove by actual figures that the process which I have now adopted is the only one which can solve the problem successfully. By this process, which consists in drying the sludge and then passing superheated steam through it, which carries with it the fatty acids, I obtain an odourless and sterilized fertilizer of the highest quality free from fatty matter and recover a considerable quantity of valuable grease, which is a further source of revenue, and I have sent you under separate cover samples of each of these products, *viz.* :— No. 1 a sample of fertilizer just as it leaves my machines, *i.e.*, without being ground or otherwise manipulated ; No. 2 a sample of the crude grease as it is recovered straight from my machinery ; No. 3 a sample of the same grease after refining.

The fertilizer is an excellent base for producing any manure which may be required for general or special purposes. It has a ready sale amongst farmers for growing cereals, root and other crops, and is also wanted for fruit growing in Canada and elsewhere. For roses and other plants it has given most remarkable results and I am even supplying it in its original state to some of the leading manure manufacturers who use it as a base for special high class manures. As regards the grease which I obtain, there is an almost unlimited market at good prices. My machinery is practically working automatically; the sludge goes in at one end of the machinery and the manure leaves it at the other end of the finished state as shown by the sample, while the grease is intercepted and continuously condensed so that the men from beginning to the end of the operations have practically nothing to do except attending to the fires.

"The cost of an installation based upon the cost of the Oldham's installation, including buildings, chimney, steam boilers and engines, and my own special plant would be in this country somewhere about £25,000 for a population of 200,000. The machinery is arranged in such manner that each set is capable of dealing with the sludge produced by about 20,000 inhabitants; thus, *e.g.*, in Oldham there are six sets, for a population of 200,000 there would be ten sets and more in proportion for any further increase in population. At present only one-third of the plant is working my complete process, *i.e.*, degreasing the sludge and producing a valuable manure and recovered grease as two-thirds of the plant are only employed for drying the sludge, whilst the dried sludge is used as fuel for further drying operations. The reason for this is that the Corporation did not realize that the manure produced would sell freely. I have, however, proved by the actual sales that it can be readily disposed of at good prices and that it is well appreciated by farmers, and as the machinery is working satisfactorily as well, the Corporation have applied for further powers to the Local Government Board to complete the plant by the addition of four more retorts, so that when this part of the installation is completed, none of the sludge will be used as fuel, but all the sludge produced by Oldham with a population of 150,000 will be made into manure and the grease contained in it will be recovered."

"The sewage of Oldham is a purely domestic one, and the sludge is obtained from it by sedimentation in settling tanks. Calculated on the dry amount of sludge, it contains on an average about 8% of fatty matter which is due to soap and kitchen refuse. The recovery of this grease, which is of a very valuable quality and can be sold in almost unlimited quantities, helps to pay the expenses of the process. I do not, of course, anticipate that the amount of grease recoverable from the sewage of a native population will be as great as that of Oldham, but the manure obtained from the sludge should be quite as valuable as that produced here, and considering that it is made on the spot, whereas any other nitrogenous manure has to be imported, it should be worth more in money value than that manufactured here and make up for any deficiency in the grease. In exceptional cases, such as small installations or where fuel was extremely dear, I have shown at Oldham that the dried sludge can be used for fuel to dry further quantities of sludge, so that apart from the commercial point of the scheme you will see that the chief feature of the process is that the sludge is completely disposed of, the dried sludge burning readily and yielding good hard clinker."

"The machinery which I have designed is working automatically, night and day, and the men never come into contact with the sludge as every thing is closed in. In the installation at Oldham there is practically no manual labour required except

that for firing the dryers, boilers, etc., and attention to the engines. Three men in 8 hour shift, *i.e.*, 9 men altogether, with a total of $9 \times 56 = 504$ hours per week, are sufficient to work up the sludge from 150,000 inhabitants. The men here get 7½*d.* per hour, so that the wages bill comes to £15-15-0 per week. Where labour is cheap and fuel dear, the plant can be designed differently, and the cost of the plant and its working can thus be reduced.

The working expenses are covered by the value of the products recovered, *viz.*, manure and grease.

In conclusion, I may say that my process can be adopted with any system of sewage purification, so that I am not tied to any special system so far as the obtaining of sludge or the purification of sewage is concerned."

I shall conclude this paper with a brief description of the Oldham sludge Disposal plant extracted from the papers at my disposal. The building in which the plant is housed is 120 feet × 45 feet × 30 feet high to the eaves and is two storied. The upper room contains six mechanical dryers arranged in pairs. The dryers are iron cylinders surrounded by brickwork and provided with flues, fire-boxes, etc. The wet sludge enters these dryers at one end and is moved automatically through them and during its passage is deprived of its water and is discharged at the other end in a dry state. The liquid which is given off as steam passes through iron pipes into a small furnace which destroys any offensive matter it may contain and from thence into the chimney.

The settled wet sludge is delivered from specially designed settling tanks by means of a screw conveyor to a bucket elevator which discharges into a feeding tank in the roof. From here the sludge is conveyed in troughs to six hoppers one above each dryer and connected with the inlets of the dryers in such a way that only a measured quantity of wet sludge can pass through in a given time; a similar measuring arrangement is provided at the outlet of the dryer so that only a measured quantity of the dried sludge can be discharged there. This dried sludge when mixed with a small amount of coke is readily combustible and can be used to dry further quantities, which in turn could be burnt to dry more sludge. The residue after burning is a hard clinker.

This, however, though getting rid of practically the whole of the sludge, is not the most economical way. The dried sludge is further treated in retorts where it is freed from the grease which it contains and which grease renders it practically useless as manure.

The dried sludge drops through the outlet measuring taps of the dryers straight into the retorts which are on the ground floor. The retorts are exactly the same as the dryers but with an additional device by which superheated steam is blown through them. The steam acting on the dried sludge, into which a small measured stream of acid flows from a cistern on the upper floor, automatically extracts the grease and carries it along with it through condensers where it is liquefied. The mixture of grease and water passes through a number of tanks in which the grease collects on the top and is removed. The dried sludge is discharged automatically at the outlet of the retort free from grease. It is absolutely sterilized; all seeds and other objectionable matter have been destroyed. It is a dark brown, odourless powder containing nitrogen, phosphoric acid, potash and above 40 per cent. of sterilized organic matter. It is of a very high manurial value and has a ready sale.

The collected grease which consists largely of stearine and palmitin is liquefied and refined and run into barrels. It is a valuable bye-product readily sold at remunerative prices.

From ordinary domestic sewage about 1,500 tons per annum of dried degreased manure is obtained per 100,000 inhabitants. The amount of grease that is abstracted from domestic sewage at home (it would be much less in this country where soap is a luxury) is 100 tons per 100,000 people ; its value is about £10 per ton in its crude state delivered at the refinery. It is easily refined at the sewage works when it becomes more valuable.

The boilers and engines are in duplicate and are 16-horse power, they work all the gearing which makes this process from beginning to end automatic. The only manual labour required is for stocking the boilers and the fires of the heating arrangement and oiling the engines. It is in my opinion, without doubt, the best method of sludge disposal.

NOTE ON THE MAINTENANCE OF A SEWERAGE SYSTEM FOR AN INDIAN CITY.

BY

MR. H. BAILEY,

Municipal Engineer, Benares.

THE proper maintenance of a sewerage system in an Indian city is a very important necessity.

Unless the Officer-in-charge has his eye on every detail of the working of the system and gives it his constant attention, things will always be going wrong. A good sewerage overseer or supervisor must be employed; a man with technical knowledge of drainage work, and not afraid of bad smells, is very desirable. He should be assisted by one or two work agents or inspectors as may be necessary and the actual working staff should be organized in gangs as under:—

CLEANING GANGS.

1. Each gang should consist of 6 men under a mate. These gangs are employed in cleaning out silt deposits in the sewers. Where the sewers are large enough the men enter them and perform the work by hand, using galvanized iron buckets which are lowered and raised from the manholes. In the case of small pipe sewers which are too small to be entered special drain cleaning rods are used. The best men should be employed on these small sewers as the cleaning rods require a certain amount of skilful handling. Careless manipulation has often caused delay in cleaning and damage to the apparatus.

FLUSHING GANGS.

2. Generally two gangs are sufficient. They are under the charge of a fitter, and attend to all the flushing apparatus. An artificially flushed system requires careful attention to its mechanical parts and all syphons, etc., are regularly inspected and adjusted.

Where the main sewer has flushing gates (as in the Benares system) they require periodical cleaning, and oiling, etc. The flushing gang also look after the automatic syphons of the flushed public latrines and pail depôts. Systematic flushing of sewers tends to prevent the deposits of silt and also prevents bad smells emanating from the ventilating manhole covers.

Repairing Gangs.

3. All repairs to sewers, surface drains, manholes, gully pits, etc., should be carried out departmentally. Each gang should consist of a mason mistri and a few coolies.

Properly constructed sewers should require very little in the way of repairs, but surface drains require constant attention on the principle of "a stitch in time saves nine" as these drains are often subjected to rough treatment by the public, and if not properly maintained fall into disrepair very quickly.

House Connections.

Where the house drains are connected direct to the branch sewers, disconnecting traps should always be used in order to prevent the passage of foul air from the sewers into the house drains, and from them into the houses themselves. The Benares pattern trap is provided with a cast-iron air inlet box which fits over the inspection eye. These traps require cleansing daily as the Indian house drain carries a lot of silt and grit from the cleansing of "cooking" vessels, etc., and frequently pieces of kunkar, stones, and rags have to be cleared out of the trap. The trap should have a water seal 4″ deep which effectually prevents the passage of air through the interceptor.

Gully Pits.

All connections of surface drains with sewers should be made through properly constructed gully pits which should be trapped by stoneware gully block traps. The gully pits require cleaning out very frequently and special gangs should be maintained for this purpose.

In European countries gully pits often become unsealed by evaporation in the dry weather, but this seldom happens in an Indian town, as the channel surface drains generally take waste water from standposts, etc.

Cast-iron gratings are usually provided. Wrought-iron gratings are sometimes used, but are not recommended.

Experience in Benares shows that a wrought-iron grating over a gully pit lasts only 5 years.

General.

The Engineer should frequently inspect sewerage maintenance work and should himself descend manholes when necessary, to satisfy himself that cleaning and repairing operations are being properly carried out. Unless well watched, this work is often scamped.

He has to remember that the drainage system under his charge represents generally a very large amount of public money which has been sunk, as it were, under the earth, in the shape of sewers to carry off the filth of the community and to render their habitations clean and healthy and that although the underground working of these drains is hidden from the public eye, any defects in the system will soon make themselves apparent on the surface.

All connections with the sewers should be carefully carried out specially in the case of stoneware pipe sewers. Saddle back junctions should always be used and great care should be taken to cut the hole in the pipe of the required shape and size without cracking the pipe.

If these connections are not properly made, landwater may enter or stoppages occur through earth entering the sewer. When a badly fitting hole is made,

cement sometimes gets forced into the pipe and by projecting inside causes obstruction.

Whilst cleaning or repairing is being done in a sewer, precautions should be taken to ensure the safety of the men so engaged. Proper lamps should be provided and men stationed at each manhole to render assistance to any one who may be taken ill or overpowered by sewer gas.

The manholes should be opened for some time before anyone descends. In Benares the standing rule is half-an-hour, in the deeper manholes longer. Disregard of this rule cost two men their lives last year in Benares.

It is advisable to have a Simonis Helmet outfit for use in very deep manholes, where experience has shown that the air is particularly offensive.

Public latrines on the water carriage system should be flushed by automatic syphons which should be regulated to flush the seat pans every 15 minutes and trough pipe at intervals of at most half an hour.

In Benares the average time is 20 minutes.

Public urinals should be fitted with continuous flushing tanks.

The weak point about public urinals is the difficulty of preventing them being used as latrines specially at night. The foregoing remarks, which are necessarily brief and undetailed, constitute the main points to be observed for the successful working of a sewerage system in an Indian city.

NOTE ON CART WHEELS AND TYRES.

BY

MR. T. SALKIELD, M.I.C.E.,

Municipal Engineer, Delhi.

WHEN the syllabus of subjects for discussion at the All-India Sanitary Conference, to be held at Lucknow in January next, was seen, in mid December, for the first time by the writer he was pleased to find, in the Engineering section, that "Width of Cart Tyres" was first on the list.

The City of Delhi is most unfortunate in the type of vehicle generally used for the transportation of heavy merchandise and building materials. This vehicle, known as a *thela*, is unprovided with springs and is the Indian champion road destroyer. For several years the author has been trying to get the Municipality to take steps to improve this type of vehicle, and many of the notes embodied herein are extracts from reports prepared by him on the subject in his capacity of Municipal Engineer.

The following dimensions are the averages of 60 *thelas* taken at random on the streets of Delhi :—

Diameter of front wheels, 1′ $7\frac{3}{8}$″.
Width of tyres............ 2·44 inches.
Diameter of back wheels, 2′ $6\frac{3}{8}$″.
Width of tyres............ 2·53 inches.

The diameter of front wheels ran from 1′ 4″ to 1′ 10″, and back wheels from 2′ 0″ to 2′ 10″.

The least tyre width was found to be $2\frac{1}{4}$″ and the greatest $2\frac{3}{4}$″.

When it is known that these carts frequently carry 60 maunds (20 maunds above the maximum allowed for 4 wheeled vehicles) it is easy to understand their road destroying capacity.

In the hope that something of historical interest might be found, telling of the thrill which was experienced by our woad painted ancestors when the most distinguished engineer of that day took out a patent for the first wheel, an encyclopædia was referred to but with disappointing results. Under "wheel" reference was made to "wheel animalcule" and under "tyre" the ancient City of that name was fully described; whilst TIRE was without definition.

The historical side of the subject, however, must not be hastily dismissed, as it is well to recall the fact that troubles, caused by unsuitable design of vehicles, date from a period probably anterior to the introduction of the first wheel. We have no record of the earliest attempts to solve the problems, but find that officers were appointed in 1555 to deal with the matter. "King James I, issued a proclamation" to "restraine the excessive carriage in wagons and four-wheeled carts to the destruction of the highways. Charles I, in 1635, limited the weight to be carried on any vehicle. Had he been acquainted with the Delhi "*thela*" his proclamation, in which the following paragraph occurs, would have been written in similar but possibly stronger language :—

"And because such extraordinary carriages have heretofore, by the opinion of the judges been .... held to be general nuisances, the King commands all Judges and Justices diligently to inquire after such offences. ...."

In 1720 " The carriage Excessive Loads Act, " was passed, and in 1744 further regulations were made about wheels and the number of horses to a wagon.

In 1773—1822—1835 Highway and Turnpike Acts were passed dealing with the same subject.

In the year 1816 several Acts were enacted which required all wheels to be truly cylindrical in form and the tyres, according to the description of the vehicle, five or six inches broad with an upright bearing.

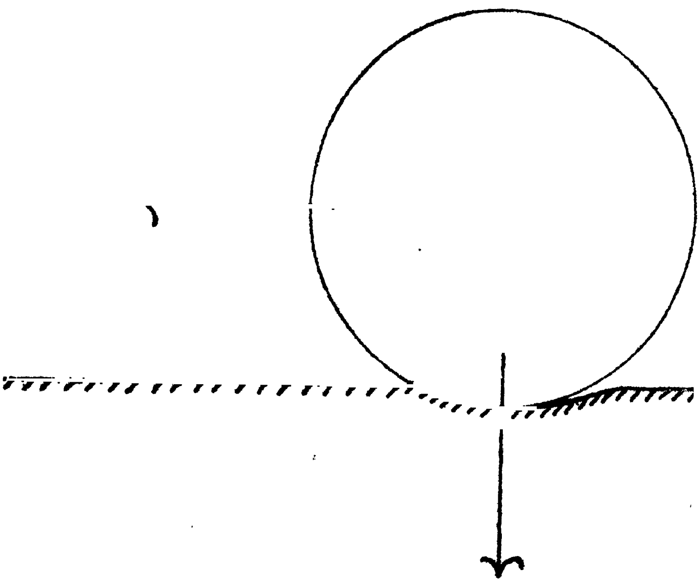
Many further Acts have been passed since 1835 and recent legislation has been concerned with the changed conditions brought about by road locomotives and motors.

The resistance to the rolling of one body on another is so very complex and offers so many mathematical problems that a series of papers with calculations could be written, but it is not the intention of the author to submit mathematical investigations to prove, amongst other things, that in resisting compression the stresses diminish as the area of action increases, but rather by means of a few broad facts to arrive at a conclusion about the width of cart tyres.

The points to be considered in dealing with this subject are :—

(1) structural arrangement of roller and rolling surface;
(2) weight of roller per unit width of surface of contact;
(3) radius and breadth of surface in contact;
(4) friction between roller and rolling surface, elasticity and resistance to shearing stresses;
(5) angle of slope of rolling surface;
(6) linear velocity of centre of gravity to the roller.

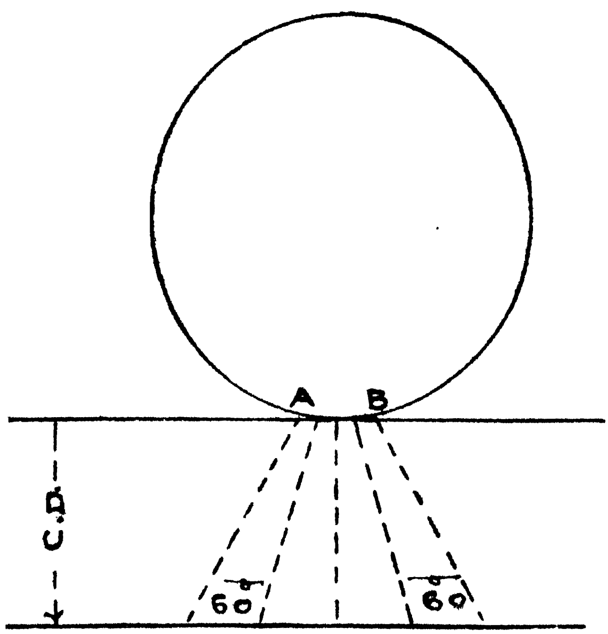
The materials of an ordinary water bound macadam road have much less elasticity than the materials of which the wheels of any vehicle are constructed, consequently the work done by the passage of wheels over such road is expended in distorting the surface and pulverising the materials of which it is composed and forming a rut out of which the wheel is constantly endeavouring to climb as described by the following diagram :—

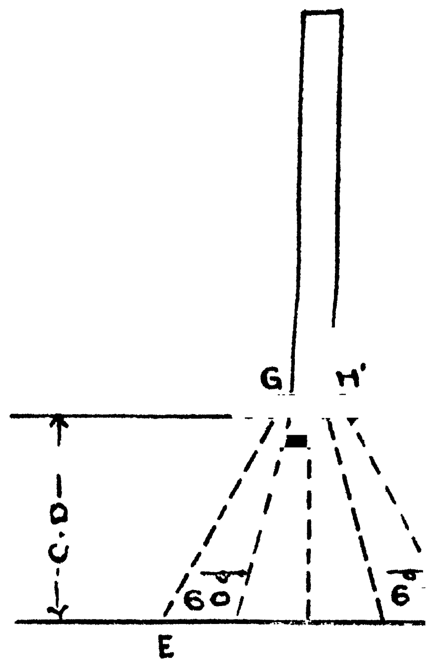


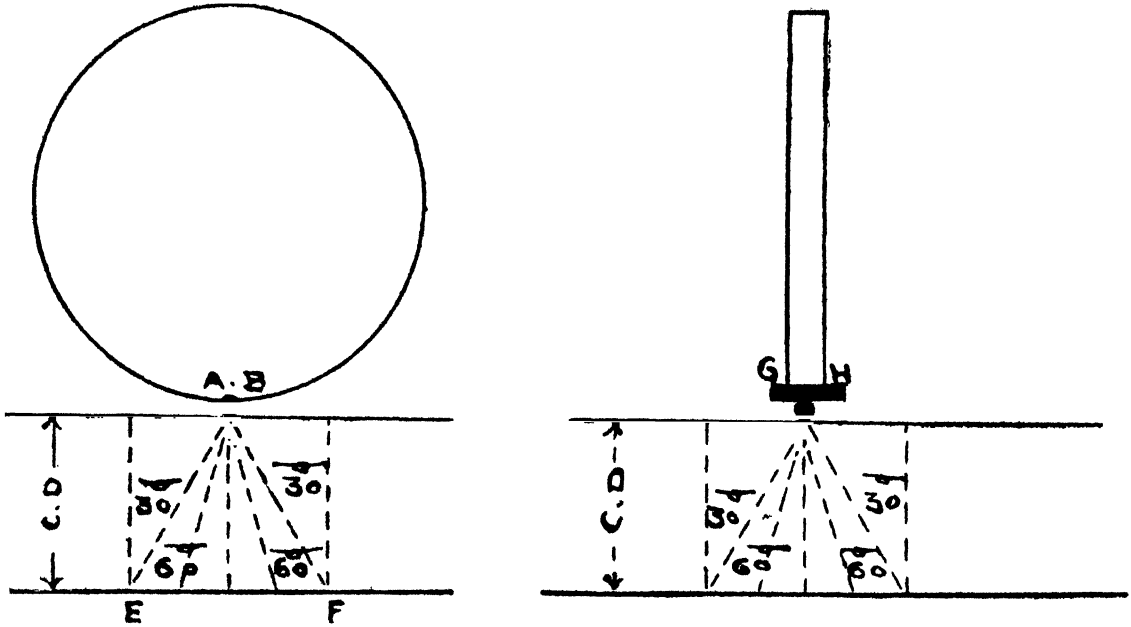
Although the syllabus mentions " width of cart tyres " only it is quite impos sible to consider this subject without regard to road surfaces and wheel diameters In all springless Indian carts, no attempt is made to reduce the friction of th wheel upon its axle and consequently the weight to be overcome is much increase and the reaction between the road surface and the wheel-tyres retarded. Th extent of such retardation depends upon the unevenness and compressibility o the road and the force necessary to overcome it which may be assumed to b inversely proportional to the diameter of the wheel. The larger the wheel th smaller is the resistance to rolling and consequently the more easily are all roa inequalities and obstructions overcome.

In Delhi fully 5 per cent. of every load of small broken stones for concret work or road renewals is dropped on to the roads from the ante-diluvian type of carts in use. These obstacles cause incalculable damage by the small wheeled springless vehicles coming into contact with them and causing the energy that is being expended in a horizontal direction to be converted into a vertical force acting downwards tending to disintegrate the road surface.

The close relationship that exists between wheel diameter and tyre width, and the pressure acting upon a smooth road surface, and the concentration of such pressure on an uneven surface or obstruction is shown by the following diagrams :—







A—B Arc of wheel in contact with road.
C—D Thickness of road crust.
E—F Lines of pressure.
G—H Width of tyre.

From this it will be seen that the distributed pressure per square inch on the subsoil must of necessity vary with :—

(1) diameter of wheel;
(2) width of tyre;
(3) thickness of road metal;
(4) camber and evenness of road surface and freedom from obstructions;

and that consequently any authority when making bye-laws should very carefully study the relationship that exists between loads, width of tyres, diameter of wheels and the general character of the roads in their district.

Such bye-laws should also contain very stringent clauses giving power to the authorities to prevent the dropping of materials from carts on to any public road.

The author has noticed in his study of this subject that the damage done in consequence of the small wheels and narrow tyres of the Delhi *thela* is aggravated by the disrepair of the vehicles as the owners allow excessive play between nave and axle and he is frequently reminded of the cutting knives on the wheels of ancient war chariots by the presence of old horse shoes doing duty for pins in keeping wheels on axle, which facts should also be remembered when preparing bye-laws.

Much could be written about :—

(1) wheels and tyres of steam and motor wagons;
(2) limit to be fixed to the width of tyres having regard to the difficulty of uniformly distributing the load in consequence of the inequalities of road surface and camber;

(3) to what extent rapid moving vehicles fitted with soft tvres such as motor-cars cause damage to roads.

The writer however dare not expand this paper much beyond its present limit, but is of opinion that it is advisable to embody the following general results of experiments that have been made upon the resistance to traction of vehicles on ordinary roads :—

(1) The resistance to traction is directly proportional to the load and inversely proportional to the diameter of the wheel.

(2) Upon a paved or hard macadamized road the resistance is independent of the width of the tyre when such quantity exceeds 4 inches.

(3) At a walking pace the resistance to traction is the same under similar circumstances for carriages with and without springs.

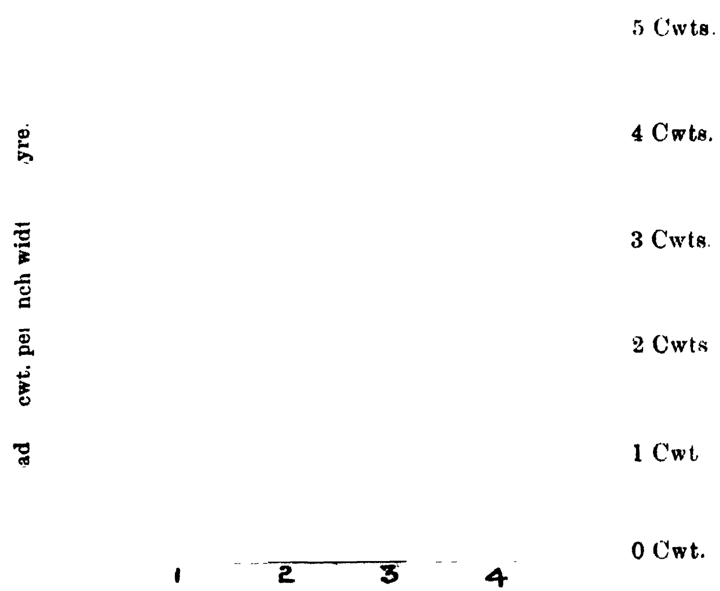
(4) Upon hard roads resistance to traction increases with velocity.

(5) Upon soft roads, earth, sand, and turf, the resistance to traction is independent of velocity.

(6) Upon compact stone paving the resistance to traction at a walking pace is not more than three-fourths of the resistance upon the best macadamized roads under similar circumstances.

(7) Road destruction is, in all cases, greater, as the diameters of the wheels are less and is greater in carriages without than in those with springs.

Having regard to these facts the maximum load that should be allowed on springless carts with wheels 5 feet diameter should not, in the author's opinion, exceed five cwt. per inch width of tyre and this should decrease in a regular ratio with the diameter of the wheels as shewn by the following diagram :—



Diameter of Wheel in feet.

In conclusion, it must be stated how very difficult it has been to keep from writing about road construction as the relationship between cart wheels and roads is so very intimate.

The author realises the incompleteness of his contribution but can only excuse himself by stating that the time available for the preparation of the paper has been very limited and that consequently he trusts its defects of omission and commission may be excused.

As a final but very important word he must draw attention to the cruelty inflicted upon bullocks as draught animals for heavily loaded carts with small wheels and narrow tyres, and trusts that public opinion will soon be aroused against the continuance of such cruelty.